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PUBLISHERS' NOTICE

We have much pleasure in announcing that Dr. Reginald Lovell, D.Sc.(Man.), Ph.D.(Lond.), M.R.C.V.S., D.V.S.M.(Vict.), has joined the Editorial staff with effect from January 1953. Sir Thomas Dalling, who now holds high office under the F.A.O. of the United Nations, has kindly consented to remain on the Editorial staff and we are very glad that he will continue to serve the Journal of which he has been an Editor since 1939, when he joined the staff following the death of Sir Frederick Hobday.

EDITORIAL

SURGICAL SHOCK

The condition known as "shock" which follows upon injury and/or surgical interference is a matter of grave concern to the surgeon. It has been recognised for a long time that the post-traumatic or post-operative death of a patient may depend upon factors other than tissue damage or loss of blood.

Many theories have been propounded to explain the phenomena but it was not until 1847, when Ludwig invented the kymograph, and a little later when Vierordt introduced the sphygmograph that men's thoughts were orientated towards the modern concept of shock.

Veterinary clinicians have recognised that shock can affect very adversely the recovery of their patients following injury or operations, but it is only in recent years, as the field of operative interference has widened, that it has

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assumed a position of supreme moment. The introduction of modern antibiotic therapy and the great advance in the techniques of anasthesia have enabled Veterinary Surgeons to explore parts of the body which were inaccessible in former times and has led them to attempt operative procedures which had been thought to be impossible.

As infection has come under more precise control and its ravages halted, it is natural that other factors, such as shock, should attain a more prominent place in the conquest of disease by surgical means. Shock and not infection is the modern surgeons greatest challenge.

If an efficient method of counteracting shock could be evolved then the field of surgery could be expanded and the percentage of beneficial results greatly enhanced. In human surgery much has been achieved to decrease the incidence of shock and to prevent established cases proceeding to a fatal termination.

These results are due primarily to the efforts which are taken to ensure the maintenance of an adequate circulatory volume prior to and during operations, and by preventing the shock phenomena becoming irreversible by a timely restoration of the circulatory function which has been lost at the time of the operation or accident.

Veterinary Surgeons are hampered in their efforts by the absence of, or shortage of, stocks of homologous plasma or suitable plasma substitute.

There are also difficulties directly associated with the lack of diagnostic aids or procedures which enable one to determine if shock be present and the degree thereof. The early stage is often missed. It is axiomatic that tissue resolution is hampered when the circulation is embarrassed by shortage in volume and in force. Such accompaniment may of its self precipitate shock.

The presentation of evidence based on controlled observation has raised hopes that the evolution of adequate blood and plasma substitutes, which could be available to Veterinary Surgeons would go far to bring this baneful process under control and enable our surgeons to sail in hitherto uncharted seas.

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GENERAL ARTICLES

THE CASE FOR A PRACTICAL APPROACH TO THE PROBLEM OF SHOCK

(Based on a Study of the Therapy of Post-operative Shock in the Dog, performed at the Veterinary Faculty of the University of Utrecht)

By A. M. HARTHOORN, D.V.Sc., M.R.C.V.S.

Orpington.

Possible Causes of Shock, and its Relation to Surgical Procedure

If one peruses the literature appertaining to the phenomenon, generally known as "shock," occasioned in association with accident or disease, two points stand out with great clarity.

First, that shock is a common sequel to such incidents, and secondly, that the opportunities for this phenomenon to occur are manifold.

Shock, as determined by the progressive loss of plasma from the circulation and ultimate hypotension, has been shown to occur not only as a result of such well-known causes as crush injury to large masses of muscle (Duncan and Blalock, 1942), gunshot wounds (Allison, Cole and Root, 1947), and profuse hæmorrhage (Zweifach and Chambers, 1944; Zweifach and Hersey, 1949), but it has been attributed to other factors of a less violent nature. All these conditions may be met with in the surgery, and include the release of tourniquets (Mylon, Winternitz and de Sütö-Nagy, 1943) and burns (Underhill, Kapsinow and Fisk, 1930; Keely, Gibson and Pijoan, 1939).

Reports on other conditions may also be found, some of which have a more direct connection with surgical interference. Among these may be mentioned intestinal distension without obstruction (Fine, 1940) and intestinal obstruction (Harkins, Harmon and associates, 1935-1937). The complication of shock in the latter conditions may have a grave bearing upon the successful outcome of operations to relieve abdominal emergencies. Other reports, such as those of Harkins and Harmon (1937) on shock resulting from complications such as peritonitis, throw a light on the circulatory condition that may be expected when the patient is also suffering from inflammatory lesions.

The inference may be drawn that many of the cases presented for surgical treatment are already suffering from incipient or actual shock. That is, that the patient's circulation may already be gravely disturbed or grossly abnormal even before he has suffered the detrimental influence of surgical procedure and anæsthesia. To attempt surgical interference at such a time, when the organism is in no state to bear further insult, will, even with proper resuscitatory aids at hand, gravely prejudice the patient's chances of recovery. To do so when there is no chance of the speedy administration of plasma or some efficient substitute, either as a routine or in case of necessity, is to reduce the chance of a successful outcome to the operation in these cases almost to zero.

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The results of investigations reported elsewhere (Harthoorn, 1952[1]) on a substantial number of cases of post-surgical shock has shown that a condition of shock is readily produced by the damages inflicted during surgical procedure alone. This means that even in the animal whose circulation is not disturbed prior to the scheduled operation, the results, for instance of handling of the viscera, loss of blood, or the cooling of the peritoneum due to exposure during laparotomy, especially in cold surroundings (see Fig. 1) may alone induce a state of shock. The finding also, that once a state of shock has supervened the animal becomes hypersensitive to the slightest injuries, suggests that the shocked organism will survive only a small fraction of the insult to muscle tissue and circulation that will be tolerated by the normal animal.

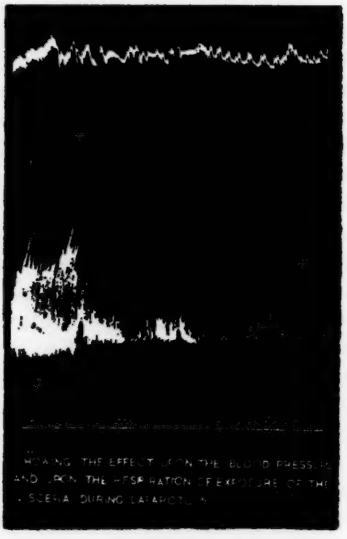

Fig. 1

The symptoms exhibited by animals suffering from post-operative shock have been recorded in some 50 cases, and these investigations are reported at length (Harthoorn, 1952[2]). Suffice to state here that in all cases a drastic reduction of the circulating plasma volume was determined, accompanied by a hæmoconcentration and ultimate hypotension. It was found that after the development of a state of shock the animal would remain, often for a space of twelve hours or more, without obvious deterioration of the condition. Little difference could be detected during this stage by observation of the blood pressure or the general condition of the animal. The only manifestation that showed progressive deterioration was the circulating blood and plasma volume. It was during this stage that the infliction of some slight injury, such as the withdrawal of an otherwise negligible quantity of blood, would often precipitate acute circulatory failure and death. Many of these animals had suffered no appreciable loss of blood, and in the ordinary course of events would have survived easily

a hæmorrhage amounting to some 20 per cent of the total blood volume. After the circulation had again been restored in these animals by infusion therapy, blood samples could once again be drawn without detrimental result.

These shocked animals certainly would not have survived another operation if this had been performed before resuscitation had been effected. If the state of shock due to some of the factors mentioned in the first two paragraphs can be compared to this state of shock following operation, the post-surgical condition of the animals studied may be compared with the state of some animals before operation, if these are suffering from some condition that by itself tends to induce shock, for instance, intestinal obstruction. The demonstration that in these shocked animals circulatory failure may be produced by the removal of only a few cubic centimetres of blood, would indicate that to embark on an operation on an animal with an already impaired circulation will greatly increase the chances of a fatal outcome.

The observations would suggest that the preliminary examination of the surgical patient, with a view to possible measures to improve or sustain the circulation, should be commenced well before the scheduled operation. It is stressed that although an operation may bring much relief, such as the removal of a source of toxic absorption, concomitant detrimental influences are unavoidable. The loss of blood that is inevitable during the division of muscle tissue, the handling of the viscera and the resulting exposure of the peritoneum, will in all cases bring about an immediate exacerbation of any degree of shock that may be present. This latter point stresses the difficuty that would be experienced in trying to prevent the precipitation of a condition of imminent preoperative shock by application to surgical technique alone, without positive counter-measures.

The Possibility of Reversing the State of Shock

It has been stated in the previous section that the shocked animal would usually remain in a state of hypotension, without signs of rapid deterioration, for many hours after a state of shock has commenced (see Fig. 2). During this time a rapid decline and circulatory failure would follow the infliction of further injury. On the other hand, during a large part of this period the circulation would show a rapid response to infusion therapy.

Although all cases of shock from which conclusions were drawn with regard to infusion therapy were fatal as judged from the death of an adequate number of untreated controls, the circulation would often show a rapid response to small amounts of infused fluid, even after the blood pressure had been at shock level for periods as long as $4\frac{1}{2}$ hours. In these cases the administration of only a few cubic centimetres of plasma or efficient plasma substitute per kilogram bodyweight would result in a rapid rise of the blood pressure with an amelioration of the shock symptoms. This showed that even fatal (i.e. fatal if untreated) shock may be reversed after periods of severe hypotension by proper attention to the restoration of an adequate circulatory volume, and the replacement of the circulating plasma colloids.

This also shows that conditions of shock, even those as severe as the ones

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which were used for these observations on infusion therapy, may remain as "reversible" shock for a considerable period of time. It is also likely from these results that milder cases of shock, even though profound enough to have a considerable effect on subsequent surgical procedure, or on the ultimate recovery of the animal post-operatively, may remain in a state of reversible shock for even longer periods.

These results would suggest that in practice, conditions of advanced shock could be reversed and the survival of the animal promoted by an infusion at the earliest opportunity of a therapeutic quantity of an efficient blood substitute. This procedure could be used to ameliorate post-operative circulatory imbalance and shock, as well as to counteract any circulatory imbalance or impending shock which may be present at the time when surgical interference is contemplated.

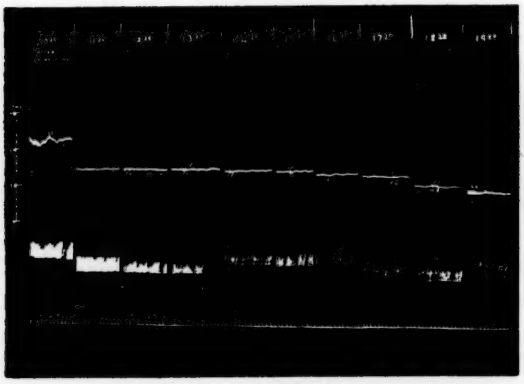

Fig. 2
A case of shock following laparotomy which was not treated, showing slow but steady deterioration of the blood pressure.

Infusion Therapy of Shock

Although circulatory imbalance and shock may be initiated by one or more of many factors, and in several different ways, the essential mechanism with which the condition maintains itself in the body, and assures its own progression, is basically similar. It was found that in all cases of shock, once the circulatory imbalance became progressive and shock commenced, the symptoms were the same. Even though the initiating factors differed from in some cases the oligæmia resulting from gross loss of blood, and in others, the largely nervous effects of exposure and handling of the abdominal contents. The reason for this appeared to be the fact that the essential mechanism of the state of shock and the resulting symptoms were intimately connected with a loss of the circulating plasma, and a consequent rise in the red cell content of the blood. Other symptoms, such as the anoxæmia as well as the stagnant anoxia, fall in body temperature, etc., could all be correlated with, and explained as a result of the impairment of the circulation.

It has been mentioned that during these investigations it had been observed from the behaviour of control animals that the relatively "good" condition of

the shocked animal was maintained for many hours until the blood pressure showed a sudden and steep fall to a level too low to maintain life. At the same time there would also be a sharp deterioration in the other symptoms and in the condition of the subject. When this phenomenon is correlated with the symptoms of evident progressive vasoconstriction and constantly diminishing plasma volume, it becomes clear that the blood pressure is only maintained at a steady level of hypotension by the " closing down " through vasoconstriction of a large part of the circulation. It is only when this mechanism breaks down that the sudden decompensation and organic failure occurs. During these investigations no animal failed to respond to correct infusion with therapeutically active fluids when still in a state of active compensation to the diminishing blood volume.

In general practice it is not easy to make an exact evaluation of the condition of the patient on account of the lack of facilities for making determinations of diagnostic criteria such as the height of the blood pressure, the extent of the blood concentration, etc. On the other hand, in the light of the findings described, it should not be impossible on the basis of ordinary clinical diagnostic procedure to gauge whether an animal is still in a responsive stage. In this way it should be possible to judge from easily detectable signs, such as the pulse pressure, respiratory frequency and depth, as well as—to the practised clinician perhaps the most important aid—the general " appearance " of the subject, firstly, whether infusion therapy should be applied, and secondly, whether it is likely that the patient will respond.

Other Forms of Therapy

A vast amount of experimental work has been carried out in the hope of finding a drug that will prevent, or reverse, the shock state. Up to date, however, no practical results have been obtained, certainly none that has been able to replace infusion therapy. Many substances have been advanced as possible therapeutic agents, only to be discarded after failure under experimental or field conditions became evident. In this way vasopressor drugs were at one time widely advocated in the attempted treatment or prevention of shock on the basis that they would compensate for the falling blood pressure. They were abandoned, however, when it was demonstrated that vasopressor agents are not only useless, but are even contra-indicated. (Freeman and associates, 1933-1941.)

At the time of the discovery of the practical uses of desoxycorticosterone, hopes were raised that a substance had been found that could be used as a specific therapeutic agent in the therapy of shock, especially as it was demonstrated that adrenalectomised animals would spontaneously go into a state of shock. (Huer, DeWitt *et al.*, 1934; Marmorston-Gottesman and Perla, 1931; Swingle, Pfiffner *et al.*, 1933.) Selye, Dosne and associates, however, showed in 1940 that in the treatment of shock with large doses of desoxycorticosterone the substance proved not only inactive, but actually harmful.

Other substances were also brought forward as possible specific substances for the treatment of shock. Sodium chloride therapy—which was suggested to

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neutralise the increment of blood potassium found in samples drawn from the circulation while the patient is suffering from shock (Tabor and Rosenthal, 1945)—was found during our investigations to be ineffective in the dog, while Rosenthal found that in the rat, sodium chloride therapy became less effective as the amount of water given with it was decreased. Moyer and associates (1944), and Wiggers and Ingraham (1945), found that the suggested sodium bicarbonate therapy was only effective when given in conjunction with blood transfusion, and sodium lactate (Fox, 1944) appears to be very much inferior under experimental conditions to plasma and whole blood. (Harkins, 1947.)

Even the brilliant work of Shorr, Zweifach and Furchgott (1945) on the prevention of irreversible shock by the injection of liver enzymes assumes less practical importance when it is realised that the state of irreversibility is primarily initiated by a prolonged reduction of the blood flow through certain essential organs such as the liver, with consequent failure in the normal dynamic functions. Also that for a large part of the time between shock induction and eventual circulatory failure and death, the normal enzymatic functions may yet be restored by proper infusion therapy (see above).

In the present state of knowledge it may be said that no treatment for shock has been discovered that can equal the restoration of the circulation by the infusion of therapeutic quantities of blood or plasma or an efficient blood or plasma substitute that is retained in the circulation and exerts an adequate oncotic pressure in the blood stream.

When Shock Therapy Should be Instituted

During the experimental infusion of blood substitutes into normal anæsthetised animals, in order to gauge the effect on the blood pressure and the plasma proteins, it was found that relatively large quantities of substances such as plasma may be infused without detrimental effect. No harm results, although the infused substance is added to the normal blood volume. These tests show that no harmful effect may be feared from unnecessary infusion therapy. On the other hand, delay in instituting therapy in the shocked animal may result in the shock becoming unresponsive to infusion therapy before the latter is commenced, or else that operative interference is commenced on an animal whose circulation is in no position to bear further insult. In either of these cases delayed action, or failure to sustain the circulation, may result in loss of life.

It is not usual in veterinary practice to determine the blood pressure of patients or to perform routine tests on the state of the concentration of the blood or the circulatory blood and plasma volumes. These diagnostic procedures are not, however, indispensable as long as adequate resuscitatory measures are taken as soon as circulatory imbalance is suspected, even if the procedure may sometimes cause infusion to be given when not strictly necessary. As a result of the lack of diagnostic methods, the demarcation line between, on the one hand, patients that need no infusion and, on the other hand, those in which infusion is essential, is much more vague. The only safe procedure remains the shifting

of the critical line determining whether infusion should be given, towards those patients where the circulatory imbalance is only suspect.

In this way infusion therapy may be given :—

(*a*) To those cases that show signs of circulatory depletion or lowered blood pressure before operation.

(*b*) During operation in those cases where the operation is unduly prolonged, or where gross loss of blood or insult to tissues makes it likely that shock is being induced.

(*c*) Post-operatively where the patient seems to make little or no spontaneous recovery, where the state of the blood pressure judged from the pulse rate and type seems abnormally low, or where the symptoms of incipient or established shock are evident.

In the first category fall those animals that are already in a state of incipient shock prior to the scheduled operation; the so-called " poor operative risk." It is evident that the condition of these animals is not reversed readily without removing the cause of the circulatory imbalance. It was found, however, during these investigations, as indeed might have been conjectured from a knowledge of the circulatory mechanism and the mechanism of shock, that in many cases shock is far easier to prevent than to cure. It such cases, therefore, the first point of the infusion is not to cure an existing depletion of the circulation plasma volume, but to anticipate further inroads on the blood volume by the loss of blood and trauma occasioned by the operation as well as by the lowered blood-loss-compensation which inevitably results from the induction of surgical anæsthesia. In these cases careful therapy may be commenced both during prolonged waiting before operation, as well as just before the operation is about to commence. In this way the pre-operative condition of the patient is supported and the operative loss of circulatory fluid anticipated.

In the second case, where the abnormal duration of the operation or large blood loss makes it likely that shock is being induced, the need for sustaining the circulation may be judged either from the symptoms shown by the patient or, and probably more easily under the conditions of veterinary surgery, by a comparison to the normal blood loss and operation times.

The symptoms that denote impending shock under these conditions have been described (Harthoorn, 1952[2]). Of these, the changes in the respiration and the weakening pulse rate are generally recognised. To this may be added the apparent deepening of the anæsthesia due to cerebral anoxia. The latter is specially evident when intravenous anæsthetic agents have been used. The animal becomes progressively less reactive even to gross stimulation. An immediate alleviation of these symptoms will in most cases follow the infusion of a fluid with a therapeutic oncotic pressure. The pulse becomes fuller, the respirations are stimulated and the depth of the anæsthesia is lightened. It was the latter that was found during these investigations, to be the most striking improvement. In several cases the animal in question was apparently deeply anæsthetised although the normal time for the anæsthetic action of the preparation used had ended some time before. The almost immediate response

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to infusion and a return to consciousness indicated that the apparent anæsthesia could be largely ascribed to diminished circulation with consequent anoxia of the higher centres.

In those surgeries where infusion apparatus is kept in readiness the institution of a drip infusion is only a matter of moments, and it may be assembled with ease by a lay assistant. The veterinary surgeon need only insert the needle in a convenient bloodvessel before the operation can recommence. In these cases, as in the first category, shock can often be anticipated, and factors such as the resulting capillary permeability prevented.

Fig. 3
The effect upon the blood pressure and the respiration of laparotomy followed by shock and a subsequent infusion.

It was also evident that even in cases of very heavy blood loss the infusion of blood had no apparent advantage over the use of, for instance, plasma. That is, in those cases where the loss of blood could eventually be checked. Even in those cases where the loss of blood was far greater than that which normally occurs, the resulting deficiency in hæmoglobin is not greater than that often found in anæmic patients, while the survival rate following blood transfusion is reported to be no higher than that which follows treatment with homologous plasma. (Ivy and others, 1943.) Careful determinations of the hæmatocrit value, both before and after infusion, indicated that so many blood corpuscles, sequestrated from the normal circulation by the physiological contraction of the blood vessels due to the depleted circulatory volume, are returned to the circulation that a relative rise in the red cell percentage could be established. In these cases an infusion of plasma had the same effect, relative to the pre-infusion hæmatocrit and the increased blood volume, as would have been expected from a substantial infusion of whole blood. (Harthoorn, 1952[3].)

In the last category, where the post-operative condition of the patient seems to be indicative of impending or established shock, or where no attempt at spontaneous recovery seems to be in evidence, most of the indications postulated under the previous heading again present themselves.

Careful and frequent control of the post-operative patient will reveal whether the condition is deteriorating, is stationary, or is showing improvement. The trend of the condition can be deduced from repeated determinations of the pulse rate and type, and the respiratory movements, as well as an assessment of the speed of recovery from the anæsthetic.

It was especially this condition of post-operative shock and collapse that was the subject of the greater part of the above-mentioned investigations. The rapid response that was found to follow correct infusion therapy in the preponderance of cases of shock of a degree that proved fatal in all untreated control animals indicated that even in those conditions where shock was established, correct therapy could result in a great decrease in the percentage of fatal results.

In all cases from which conclusions were drawn, repeated measurements of the plasma volume and determinations of the blood pressure indicated beyond all doubt that the condition that was being treated was progressive. In several of the cases therapy was withheld for as long as 4½ hours after the blood pressure had fallen to shock level, without preventing the ultimate recovery of the subject. In most cases the period that was allowed to elapse after the blood pressure had fallen to shock level was 2½ hours. This was the minimum period employed in any of these investigations, and was thought necessary to ensure that spontaneous recovery was not taking place. Fig. 3 shows the typical blood pressure tracing obtained from an animal whose blood pressure had fallen as a result of operative procedure and where successful therapy resulted in a rise of the blood pressure and utlimate complete recovery. The curve was typical of the many blood pressure tracings that were obtained during the treatment by infusion with therapeutically active substances, of hypotension in the 50-odd cases of surgical shock investigated. Of the cases of established fatal post-operative shock treated with therapeutically active substances, more than 88 per cent survived. Of the animals in an identical depth of shock that received no treatment, the mortality rate was 100 per cent.

Discussion

Observations based on the study of a substantial number of post-operative cases have indicated that shock is a common complication of operative procedure. This can be ascribed both to the fact that many of the patients presented for surgical treatment are already in a state of shock or impending shock, and also because prolonged or severe surgical interference is capable of alone producing such a depression of the normal body functions that shock results.

The investigations on which these conclusions were based show that conditions of established shock are progressive and are essentially a vicious circle of oligæmic and stagnant anoxia and further capillary damage and plasma loss. It was also shown that for comparatively long periods the shocked animal could remain in a state of only slow deterioration of the responsive state. During this time, restorative therapy in the form of an infusion of therapeutically active material would in most cases be readily effective.

The results of these investigations indicate that with the correct use of adequate blood substitutes, such as homologous plasma,* a great reduction can be effected in the mortality rate which results when surgical interference is

* Practical methods for the administration of therapeutically-active blood substitutes have been evolved and the results will be described in another article.

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complicated by shock. They also show that a re-establishment of the circulation, often by only small quantities of such fluids, is an essential preliminary to further treatment, and in many cases to the recovery of the patient.

Studies made on the therapy of cases of established shock have indicated that even severe shock may be reversed by timely replacement therapy. All the animals upon which trials of blood substitutes were made were shown, by means of careful measurements of the circulating blood and plasma volume, blood pressure, etc., to be in at least such a state of shock as that which proved to be fatal in 100 per cent of the untreated control animals.

These results would indicate that a substantial reduction of the mortality rate due to post-operative shock may be expected if timely infusion therapy be instituted in those cases where clinical symptoms indicate circulatory imbalance and impending or established shock.

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THE SHEEP-DOG—ITS MANAGEMENT AND FEEDING
A Preliminary Survey

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Introduction

DURING the last 40 years the proper management of the house-dog has received considerable attention. In this period, too, the dog has served extensively as an experimental subject to the physiologist and nutritionist, and much exact knowledge has certainly accrued from that. Still, throughout the ages, little if any change has been made in the day-to-day feeding of the house-dog and, indeed, no very obvious change in his diet is called for now. This is because it has been known since primeval time that the dog could be maintained in perfectly good health on a subsistence derived from the broken meats off his master's table. As a result, and since long ago, the dog's natural, wholly carnivorous habits have become changed to those of omnivorous man. Indeed, in the case of certain working dogs this change in feeding practice has proceeded a stage further, so that food of vegetable origin has now almost wholly replaced animal flesh. This is particularly true of the sheep-dog, whose diet very often consists entirely of cereal meals.

Under war-time conditions when the supply of foods, particularly those of animal origin, was strictly limited, many house-dogs were maintained in apparently good health on a diet largely composed of cereals; but such dogs lived in a sheltered environment and were not required to expend any considerable energy in physical exertion. The sheep-dog, however, because of his general conditions of life, the almost unvaried sameness and austerity of his diet, and also because of the peculiarly specialised kind of work he has to do, is far removed from the house-dog. Even among other working dogs he is in a distinct class by himself.

In Scotland there are nearly 11 million acres of rough moor and hill land (considerably more than half the country), and the great mass of this area is utilised only for sheep grazings. In Scotland and also in Wales the number of sheep actually exceeds that of the human population (1.3 : 1). Extensive areas in the North of England and down the great Midland hill-range, the Pennine Chain, also consist very largely of hill grazings.

Without the sheep-dog wide tracts of Britain would have remained barren and unproductive; indeed, even on the enclosed park lands which, particularly in England, cover such extensive areas of country, sheep husbandry in the absence of the sheep-dog would be impossible and the nation's wealth of wool and mutton could not be produced. "No dog, no sheep," has become a trite truism.

The working sheep-dog is generally regarded as an eminently vigorous beast. He is! He has to be! Should his physical fitness evidently fail, he becomes unfit for his work which, especially in hill country, is arduous. This does not

imply that he is always in robust health. The sheep-dog's sense of duty and his innate readiness to respond to his master's bidding may call forth reserves of energy that are often much greater than he can properly afford to expend. If this should result in impairment, even in temporary impairment, of his health, the hill dog soon becomes useless for his work and is either destroyed or is transferred to a lowland farm on which the conditions are easier. In other words, while the working hill dog is a vigorous animal organism, only his fitness permits him effectively to meet the hard and exigent conditions of his life. These facts are so familiar to all who are concerned in sheep husbandry that they have come to be taken for granted.

The majority of sheep-dogs in Scotland and Wales and also in the Northern counties of England are of the "Border Collie type." This is a relatively small, alert and very agile dog, weighing from about 30 to 50 lb. and measuring about 18 to 22 inches at shoulder height. Some are "smooth skinned" but the great majority are rough-coated. The rough coat gives protection and warmth and with this in view it is desirable that the under-coat be soft and dense and that the overlying hair should not be shaggy or unduly long because in winter time such coats tend to become matted and entangled with frozen snow.

The sheep is a farm animal that is maintained under conditions near to those of Nature and the shepherd's calendar is therefore closely governed by the seasons of the year. These are occupied with widely different operations several of which require much concentrated activity and attention in addition to the ordinary day-to-day care of the flock. The energy-expenditure of the sheep-dog, therefore, varies widely with the season, but even in that season which is normally free from "big occasions"—the winter time—it is still very considerable, while the inclemency of winter weather with all that that implies in exposure to cold (often extreme cold) and wet (often prolonged wet) must, in itself, make heavy demands upon the dog's physical resources.

To attempt to compute the daily average distance which a hill sheep-dog travels in lambing-time must be, at best, mere guess work. The shepherd's day extends from dawn to dark, and often well into dark. During the lambing months of March and April there is daylight for some 12 hours or so, and I have found it to be generally agreed that the hill shepherd during this time may walk each day a distance of 20 to 25 miles and, of course, the dog must travel several times this distance.

Mr. A. P. Clark, farmer, Blackhope, Midlothian, has measured, by means of a pedometer, the distance he covered daily during a lambing season. The ground at Blackhope is typical Moorfoot hill land, steep in places, rough and broken with many coarse tussocks and wet, mossy areas. Mr. Clark found that during each of the 28 busiest days of lambing he travelled a distance of 30 miles; during the remaining fortnight of the lambing-time he travelled about 25 miles daily. Two dogs were employed and it was estimated that each covered, at least, three times these distances, but as one of them—a bitch—was fitter than the other she performed the greater part of the work and probably traversed more than 100 miles each day.

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When one considers that often much of the dog's work is steep and rapid hill climbing his daily energy-expenditure in physical exertion must be immense.

Further, throughout the year the dog is usually confined at night in an outhouse—often draughty and cold—where he is given a hard bed. If bedding, such as straw or bracken, be afforded it is usually sparse and scanty. Such conditions require the expenditure of a considerable amount of energy even to maintain body-heat.

It is not suggested that this Spartan regimen is basically wrong. In principle it may be quite sound; indeed it has long been believed by shepherds that any kind of coddling tends to promote a " softening " of the dog, both temperamentally and physically, and that this depreciates his working qualities: nor can it be said that such treatment indicates carelessness for the dog's welfare, because many dogs that are managed in this way are held by their masters in affectionate regard.

The sheep-dog by his qualities of sagacity, fidelity, deep sense of duty, and by his valuable services to the community has called forth universal admiration, but, queerly enough, he has attracted very little attention in respect of the betterment of his health and general well-being.

While there is good evidence that sheep-dogs (with some few exceptions) receive a sufficiency of food, it seemed to me that their usual diet was not only grossly ill-balanced but was probably deficient in several essential food factors and that, although the sheep-dog maintained a remarkably efficient plane of physical fitness, it was likely that by making quite simple corrections in feeding and possibly also in management the health of the dog could be improved and his effective life prolonged.

Investigation

With these considerations in mind I projected a general survey of the conditions under which sheep-dogs, particularly hill sheep-dogs, are maintained in different parts of Britain. This was done by means of a questionnaire. It seemed likely that, although every answer received might not be accurate, the information could be accepted as giving a fair reflection of the general state of affairs.

No attempt was made to ensure that the distribution was strictly random and the returns upon which the following data are based were those that covered the first 500 dogs in Scotland, the first 100 in Wales and the first 100 in Northern England, irrespective of the conditions, or of the districts from which they were obtained. While this somewhat haphazard method may be criticised by the statistician, the remarkable similarity of the answers seems to obviate the need for a more critical analysis.

Replies were received from 194 shepherds in Scotland, 43 in Wales and 33 in Northern England (see Tables 1 to 3).

In Scotland 23 of the 33 counties were represented, the exceptions being Ayr, Banff, Bute, Clackmannan, Dunbarton, Kinross, Moray, Nairn, Renfrew,

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and West Lothian; in Wales the returns were obtained from Caernarvon, Cardigan, Merioneth and Montgomery, and in England from the counties of Northumberland, Cumberland, Westmorland, the East and West Ridings of Yorkshire, and Lancashire.

An attempt was made to classify the returns into two sets—"normal" and "difficult"—according to the nature of the work the dog was required to perform. It was recognised that such differentiation was, of course, quite arbitrary. In point of fact, the differences in the figures relating to these two classes were found to be of no statistical significance; therefore only the total figures have been taken into consideration.

The questionnaire was issued in English and Welsh and was devised thus:—

ANIMAL DISEASES RESEARCH ASSOCIATION
Moredun Institute, Gilmerton, Edinburgh, 9.

THE SHEEP-DOG

Flockmaster ..... Farm .....
Shepherd ..... County .....

Breed of sheep	Number of sheep in shepherd's charge	Number of *working* dogs kept	Is flock eligible for Hill Sheep Subsidy?	If not, are the dogs' working conditions specially difficult?

	A	B	C	D
1. Name of dog				
2. Age				
3. Sex				
4. Weight (approx.)				

5. Age at which dog starts serious training.....
6. Length of life of working dogs (average).....years
7. Usual cause of stopping work.....

KENNELLING: (*a*) Kept in shepherd's house..... (*b*) Kept outside.....

Bed: 1. Dry earth.
2. Wooden bench.
3. Cement.

(*a*) with..... (*b*) without.....straw or other bedding.

Is dog confined by chain during non-working hours?.....

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FEEDING: Nature of food:—
1. *Cereal meal*—composition.

2. *Supplements*:
(*a*) Flesh food.
(*b*) Milk.
(*c*) Green vegetables.
(*d*) Cod liver oil, etc.

Average quantities of dry meal fed to each dog daily:

3. Time or times of feeding.....

COMMON DISEASES—Skin affections, etc.:

REMARKS:

Nature of feeding for puppies between weaning and entry to training:

Conditions of Management and Feeding

The information furnished by the questionnaire, now to be considered, is summarised in Tables 1, 2 and 3.

TABLE 1

MANAGEMENT

	Scotland	*N. England*	*Wales*	*Totals*
Working dogs ...	500	100	100	700
Shepherds	194	33	43	270
i.e., working dogs per shepherd...	2.58	3.3	2.32	2.6
Male dogs ...	284 (57%)	60 (60%)	58 (58%)	402 (57%)
Female dogs ...	216 (43%)	40 (40%)	42 (42%)	298 (43%)
Starts training (months) average	10	10	12	10.8
Stops work (years) average ...	8.5	8.95	9.5	8.78
Kept outside ...	474 (95%)	97 (97%)	100 (100%)	671 (96%)
Kept inside ...	26 (5%)	3 (3%)	0 (0%)	29 (4%)
Bedding:*				
(*a*) *Dry earth* ...	32 (7%)	21 (22%)	3 (3%)	56 (8%)
With straw, etc.	25	21	3	49
Without straw, etc. ...	7	0	0	7

* Scotland 474 dogs reported on; Northern England 96 dogs reported on; Wales 94 dogs reported on.

TABLE 1—*continued*

	Scotland	*N. England*	*Wales*	*Totals*
(*b*) *Wooden bench*	379 (80%)	62 (65%)	31 (33%)	472 (71%)
With straw, etc.	309	45	21	375
Without straw, etc. ...	70	17	10	97
(*c*) *Cement or stone*	63 (13%)	13 (13%)	60 (64%)	136 (20%)
With straw, etc.	63	13	55	131
Without straw, etc. ...	0	0	5	5
Not chained during non-working hours	417 (83%)	64 (69%)†	65 (65%)	546 (79%)
Chained during non-working hours ...	83 (17%)	29 (31%)	35 (35%)	147 (21%)

† 93 dogs reported on.

TABLE 2

TYPE OF FOOD

	Number of shepherds' reports	*Brose*	*Milk (when available)*	*Cod Liver Oil*
Scotland	194	188	168	90
Northern England ...	33	31	18	8
Wales	43	33	34	7
	270	252 (93%)	220 (81%)	105 (39%)

TABLE 3

FEEDING TIMES*

	Morning	*Evening*	*Both*
Scotland	2	107	83
Northern England ...	0	26	6
Wales	5	14	23
	7 (2.6%)	147 (55·3%	112 (42.1%)

* As reported in 192 shepherds' returns from Scotland; 32 from Northern England; 42 from Wales=266.

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(1) THE SHEEP-DOG'S WORKING LIFE

Usually, young dogs are entered for serious training when they are about nine to 12 months old. Some dogs show a remarkable precocity at a very early age—three to four months—when they may drive, and control the movements of, groups of poultry in the farmyard. This play is engaged in quite spontaneously and appears to be instinctive. Other dogs are relatively slow in developing the herding sense and may be 18 months or more before they show signs of being fit for serious training. These signs of "shaping for work" are difficult to define but are readily recognised by experienced shepherds, many of whom do not attempt to "run" a young dog until he himself asks to be trained.

Quite often the precocious pup in later life does not fulfil his early promise of skill and sagacity. On the other hand, the slow beginner may develop into a sheep-dog of extraordinary ability. In these respects collies have their human counterparts.

It is difficult to determine the specific causes of a dog's becoming unfit for active, efficient work but there seems to be little doubt that the main causes are those associated with advancing age. In hill dogs the signs of general physical incapacity begin to become evident about the age of 6 or 7 years. Thereafter they progress in greater or less degree and this, of course, results in an ever-lessening fitness for effective service.

The shepherd has to decide when, in the process of this progressive decline, the dog should be replaced by a younger and fitter successor, but he is naturally reluctant to put an end to the services of a trusted servant who is growing old, but who (if just because he is growing old) has acquired the experience that is reflected in deeper wisdom and greater reliability and skill.

In several of the replies received the maximum ages for hill dogs are stated to be 10 or more years. This should be accepted with considerable reserve because these ages are exceptional; it has been found that they often refer to certain favourite old dogs which the shepherd has possessed at one time or another. Taking this into account and considering the remaining evidence furnished by the returns, it would seem that the average life of the working sheep-dog is about eight-and-a-half years. It should be emphasised, however, that a considerable number of dogs do not complete their normal working span but are deliberately destroyed, often at a comparatively early age, as a result of their having contracted some disability which, although it may be relatively slight in itself, renders the animal unfit for fully satisfactory work.

In almost all cases the reasons given as the actual causes of the dogs' stopping work can be epitomised as "general decrepitude" comprising undue respiratory distress and fatigue following calls for exertion; "stiffness"; failing eyesight or hearing.

(2) KENNELLING CONDITIONS

With few exceptions sheep-dogs are kennelled in a shed or other out-building (96 per cent of the returns, see Table 1).

The usual bed is a wooden bench laid on, or raised some few inches above, the floor (71 per cent). Straw, bracken or other litter is commonly provided but often the bed consists only of bare boards. In some cases the dog is bedded on dry earth (8 per cent) and in others he lies on cold cement or stone (20 per cent) which, however, is almost always covered with matting or with differing amounts of straw, sawdust, etc.

The great majority of dogs (79 per cent) are not confined by chain during non-working hours.

(3) FEEDING: The Adult Working Dog

Almost invariably (93 per cent of the returns—Table 2) the staple of the sheep-dog's diet is oatmeal or maize meal, given, either separately or mixed together; to this a little common salt is added, and a brose is made by the addition of boiling water.

In the great majority of cases (81 per cent) milk, either whole or skimmed, usually varying in amount from about a half to one pint, is given daily when it is available.

Animal flesh, apart from odd table scraps, is very rarely fed. (In any case, the quantity of remnants from the household table—especially in these days—is almost negligible). Rabbit flesh is fed only occasionally and is not to be regarded as part of the routine diet. The mutton from a sheep that has died (if it be at all edible) may be boiled and fed to the dogs, and at lambing time the placentæ of the ewes are eaten voraciously. But such opportunities afford only random festive orgies.

From this it will be apparent that the proteins in the sheep-dog's daily diet are practically all of vegetable origin.

Green vegetables, except as table scraps, are rarely fed. In a considerable number of cases (39 per cent) cod liver oil is given as a regular or—more frequently—as an occasional supplement.

Many shepherds (55 per cent) give only an evening meal (Table 3) except during lambing time when the dogs are fed in the morning also; but two feeds daily are commonly given (42 per cent), one in the morning before starting work, the other (the main meal) in the evening after the day's work is over. In relatively few instances the feed is given only in the morning.

There is considerable variation in the weights of cereal meal fed to different dogs. The weights of dry meals, as recorded by shepherds, range from about ½ lb. to 2 lb. per dog. It might be presumed that such wide differences depend upon the size of the dog, the nature of the work, and also upon the climatic conditions, that may prevail. Several of these statements, however, may have been made in error because in many cases the amounts of dry meals fed from day-to-day are roughly assessed by the handful or by some other convenient capacity measure (a tankard or similar container) and as much is given as the dog will eat—if food is left uneaten the amounts are reduced; if his appetite calls for more food he gets it.

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From the information disclosed in the returns the common daily ration of the sheep-dog may be considered to consist of a mixture of ½ lb. maize meal, ½ lb. oatmeal and ½ pint of milk, and this will be referred to in the subsequent text as the "*Sheep-dog's Basic Ration.*" The phrase is used here merely for convenience. It does not imply that it represents the average ration of all those examined but is to be interpreted as a general standard of measurement.

Calories

Woodman (1948) gives the composition of flaked maize, oatmeal and milk as follows:—

	Digestible Protein %	*Digestible Fat* %	*Digestible Carbohydrate* %
Flaked maize	9.9	2.7	69.5
Oatmeal	9.6	4.1	43.2
Milk	3.2	3.9*	4.8

* Skimmed milk=approx. 0.5 per cent fat

The commonly accepted Calorie values for digestible protein, digestible fat and digestible carbohydrate (Wood, 1927) are shown below:—

1 lb. dig. protein =2,133 Cal.
1 lb. dig. fat =4,000 Cal.
1 lb. dig. carbohydrate=1,707 Cal.

From this we obtain the following as the Calorie values for 1 lb. flaked maize, 1 lb. oatmeal and 1 pint milk:—

1 lb. flaked maize=1,505.5 Cal.
1 lb. oatmeal =1,106.2 Cal.
1 pint milk = 382.7 Cal.

From this the Calorie value of "The Sheep-dog's Basic Ration" is calculated to be approximately 1,500 Calories as shown below:—

1 lb. mixture of approximately equal parts of flaked maize and oatmeal	=1,305.8 Cal.
½ pint milk	= 191.3 Cal.
	=1,497.1 Cal.

According to Dechambre (1919) it may be calculated that the maintenance needs of a 33 lb. dog are 1,080 Cal.; of a 44 lb. dog, 1,265 Cal.; of a 55 lb. dog, 1,480 Cal. and of a 66 lb. dog, 1,690 Cal.

Energy requirements for work do not appear to be known for the dog. The only farm animal whose energy needs are available in respect of different classes of work is the horse (Dechambre, 1919); for this animal 30 per cent should be added to the maintenance ration for light work, and 75 per cent for heavy work. It is doubtful, to say the least, whether these values also apply to the dog; but on this basis the working dog's requirements would be as follows:—

Calculation of Calorie Needs for the Working Sheep-dog

Weight of Dog	22 *lb.*	33 *lb.*	44 *lb.*	55 *lb.*	66 *lb.*
Maintenance (say 18 hours)	642	810	948	1,110	1,266
Maintenance + light work (say 3 hours)	139	176	205	241	274
Maintenance + heavy work (say 3 hours)	187	236	277	324	369
Total ...	968	1,222	1,430	1,675	1,909

It would thus appear that the ration of approximately 1,500 Calories (see above) for a hill sheep-dog doing an *average* day's work is little more than adequate for a 44 lb. dog (1,430 Calories) and that it is less than adequate for heavier dogs.

The results of these calculations, while interesting and possibly significant as general indications, are not of any real value in their direct, practical application because, as has been indicated, the dog is usually given just as much food as he wants to eat and his appetite for food varies with the conditions of his work, the prevailing climatic conditions, etc. In other words, there is no evidence that the sheep-dog does not receive a sufficiency of Calories.

Minerals

Calcium : Oatmeal contains 0.317 g. per ½ lb. and maize meal 0.045 g. calcium per ½ lb., while flaked maize contains only a trace of this important mineral.

Cow's milk, whether whole or skimmed, is a good source of calcium (about 0.45 g. per ½ pint) and the calcium in milk is in a very readily assimilable form. In practice, however, many dogs either receive no milk at all or only when it happens to be available, and then often only in small quantities.

Certainly a rich source of both calcium and phosphorus is provided by beef- or mutton-bones, although the amount of these substances that the dog actually ingests and assimilates by gnawing bones may be much less than is generally supposed. It is also true that in these days bones are not always easily obtained from the butcher. Rabbit- and chicken-bones are usually (and very properly) excluded from the diet because when chewed by the dog they splinter and can be the cause of serious injury.

For a 40 lb. dog Whitney (1949) states that 1 g. calcium daily is an ample allowance; but for a dog of this weight Linton (1950) gives 2.2 g. as the daily calcium requirement.

If we can accept either of these figures it would appear that the sheep-dog's "basic ration" (0.8 g.) is low in calcium. The matter becomes the more important in light of the following considerations.

Harrison and Mellanby (1939) showed that phytin, a substance present in certain cereals, particularly oatmeal and maize meal, is antagonistic to the calcification of bone and is thus a rickets-producing factor. Later work

(Mellanby, 1949) proved, however, that dogs maintained on a diet consisting largely of oat- and maize meals (a diet therefore rich in phytin) were able to form perfect bone so long as the food also contained adequate amounts of both calcium and vitamin D.

Since the sheep-dog's "basic ration" consists so largely of oat- and maize meals and is therefore so very rich in phytin, and since it is questionable whether it contains a sufficiency of vitamin D (see under vitamin D) it is difficult to equate the sheep-dog's apparent fitness with the opinions of the nutritionist.

Phosphorus: Oatmeal is relatively rich in phosphorus (1.84 g. per ½ lb.); maize meal and flaked maize also contain it in considerable quantity (0.885 g. and 1.36 g. respectively per ½ lb.). Both whole and skimmed milk are good sources of phosphorus (0.567 g. per ½ pint) but considering the random way and the small quantities in which milk is often fed to the sheep-dog it cannot be regarded as affording a reliable supply.

Whitney (1949) states that 1 g. phosphorus is a fully adequate daily allowance for a 40 lb. adult dog. McCay's (1949) and Linton's (1950) figures are in agreement with this. It would thus appear that the sheep-dog's "basic ration" is adequate in phosphorus.

The calcium and phosphorus in cereal foods require for their full utilisation adequate amounts of vitamin D (see under Calcium above). It was at one time believed that when calcium and phosphorus are both present in the diet in a completely assimilable form they should be in the ratio of 1.2:1. Recent evidence suggests that the ratio is of relatively minor importance provided there is a sufficiency of both elements available in the diet.

Magnesium: While it is recognised that magnesium plays an essential part in the dog's metabolism its functions are still very imperfectly understood.

Maize meal contains practically none, but oatmeal contains an appreciable quantity (0.329 g. per ½ lb.). Cow's milk is low in magnesium (0.034 g. per ½ pint).

The magnesium requirement for the dog is unknown but is assumed to be very low. There is no evidence to suggest that the "basic ration" for the sheep-dog is other than quite adequate in respect of this element.

Potassium, Sodium, Chlorine: Winston (1951) gives the daily needs of potassium as 0.6 g. Vegetable foods are generally rich in potassium which is present in quantity in oat- and maize meals (1.25 g. and 0.749 g. respectively per ½ lb.). Vegetable foods, however, are very low in their content of sodium and also of chlorine. According to Winston (1951) the daily requirement of sodium chloride for the dog is about 0.5 g.

There is a loss of sodium from the body when the diet is rich in potassium and on such diets sodium should be fed as a supplement. Maybe, because of this underlying reason, it has for long been customary to add a little common salt as a "savour" when preparing meal brose.

Iron: The importance of iron in animal metabolism is realised too well to require other than passing reference. Oatmeal contains 11.8 mg. of iron per ½ lb. and maize meal 2.04 mg. per ½ lb.

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It has been calculated (McCay, 1949) that a medium-sized dog probably requires 1 to 2 mg. of iron daily. The "basic ration" of the sheep-dog would therefore appear to be quite adequate in this respect.

Other Elements: It is considered that the sheep-dog's "basic ration" should be quite adequate in supplying the trace amount of iodine required and certainly there is no clinical evidence of iodine deficiency. Also it may be fairly safely assumed that sulphur and the trace elements, e.g., copper, manganese, cobalt and zinc, are also available in adequate quantity.

Vitamins

For convenience the vitamins which principally concern us here are grouped as follows:

The fat-soluble vitamins:
Vitamins A, D and E.

The water-soluble vitamins:
Aneurin (vitamin B_1), riboflavin B_2), nicotinic acid and vitamin C.

Other members of the vitamin B complex, e.g., pantothenic acid, pyridoxine, choline, biotin, folic acid, etc., are at present regarded as of minor importance in practical dietetics.

Fat-Soluble Vitamins

Vitamin A: The daily needs of vitamin A for a 40 lb. dog would appear to be about 450 to 500 I.U. (Michaud and Elvehjem, 1943-44). Milk is usually a rich source of vitamin A (about 1,500 I.U. in 100 g., say 4,300 I.U. in $\frac{1}{2}$ pint). Carotene, the precursor of vitamin A, is obtained from many vegetable sources; its content in yellow maize meal is of a high order.

The sheep-dog's "basic ration" thus seems to be adequate in respect of vitamin A.

Vitamin D: Most foodstuffs other than fish oils, animal fats and dairy products are relatively poor sources of vitamin D. The vitamin is almost entirely absent from vegetables, and it is now believed that it does not occur at all in the green leaves of plants. However, animals can elaborate vitamin D in their own tissues when their skin is exposed to the ultra-violet rays of the sun and it is probably by this means that the sheep-dog largely obtains his needs of vitamin D since milk is often absent from, or is poorly represented in, his diet. Milk is, however, a very valuable source of vitamin D because although this vitamin occurs in milk in relatively small amounts (two I.U. in 100 g.; say about six I.U. in $\frac{1}{2}$ pint) it is present in a form in which its bone-forming properties are much enhanced. The presence of a modicum of fat in the diet is believed to facilitate the assimilation of vitamin D.

Among the principal functions of vitamin D are those that concern the normal growth of the skeleton and the maintenance of the skeletal structures in a sound, healthy condition throughout the life of the adult animal. These functions cannot be fulfilled, however, unless the diet contain adequate amounts of calcium and phosphorus; this is particularly important if the food is rich in phytin (see under Calcium).

While it may be assumed (although with very considerable reserve) that

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the sheep-dog obtains directly from his diet, or indirectly by other means, his ordinary requirements of vitamin D, any lack of this vitamin can, of course, be made good by the addition to the food of a small quantity of cod liver oil or halibut liver oil in both of which, particularly the latter, the vitamin is highly concentrated. It will be seen from Table 2 that 39 per cent of the reports mention the use of cod liver oil.

Vitamin E: Very little seems to be known about the needs of the dog for vitamin E although it has been stated that the daily requirement of vitamin E for a 40 lb. dog is about 18 mg. (Michaud and Elvehjem, 1943-44). Its importance in preventing muscular dystrophy is now well recognised but several authorities consider that one of its most important actions is that of assuring a full utilisation of vitamin A and of carotene in the diet.

While wheat-germ is perhaps the best source, maize meal is relatively rich in vitamin E (10 mg. per 100 grams) and oatmeal contains it in considerable quantity. The vitamin is present in milk provided the cow's diet is rich in vitamin E. It is practically absent from dried milk products, and cod liver oil contains very little.

On the above considerations it may be assumed that the "basic ration" of the sheep-dog is adequate in vitamin E.

Water-Soluble Vitamins

Aneurin: Oatmeal contains a very considerable quantity of this vitamin (540 μg. per 100 grams or 1.2 mg. per ½ lb.) and maize meal contains 150 μg. per 100 grams or 0.34 mg. per ½ lb. Milk contains about 0.12 mg. per ½ pint.

The "basic ration" thus contains about 1.7 mg. of aneurin.

It has been estimated (Michaud and Elvehjem, 1943-44) that the daily needs of a 40 lb. dog for aneurin are about 0.27 mg. For pregnant and lactating bitches about double this amount may be required.

If these figures can be accepted as reasonably accurate it would seem that the "basic ration" is ample in respect of aneurin.

Riboflavin: Oatmeal contains 100 μg. per 100 grams or 0.22 mg. per ½ lb. Maize meal contains 63 μg. per 100 grams or 0.14 mg. per ½ lb. Milk contains about 0.42 mg. per ½ pint.

The "basic ration" thus contains about 0.8 mg. of riboflavin.

According to Michaud and Elvehjem (1943-44) the daily needs of a 40 lb. dog for this vitamin are about 0.45 mg. The "basic ration" is therefore probably also adequate, although riboflavin may be deficient in a diet in which milk is not well represented.

Nicotinic Acid: In the sheep-dog's "basic ration" the cereals contain considerable quantities of nicotinic acid (maize meal 17.6 and oatmeal 6 to 11 μg. per gram) and milk contains 0.8 to 1.0 μg. per gram.

From this it may be calculated that the "basic ration" contains about 6 mg. of nicotinic acid. The daily requirements of a 40 lb. dog for nicotinic acid are given by McCay (1949) as 4 mg. while on Krehl's (1947) figures they can be calculated as from 3.6 to 7.2 mg.

From the above it might be inferred, *prima facie,* that the amount of nicotinic acid in the " basic ration " is about adequate. It is recognised, however, that maize contains some substance that prevents the full assimilation of nicotinic acid. Indeed Krehl and his co-workers (1945) have found that the dog's requirements of this vitamin are increased about three-fold when large amounts of maize products are included in the ration. Dogs can probably synthesise nicotinic acid in their intestine provided that there is an ample supply of the amino-acid tryptophane. Maize protein, however, contains practically no tryptophane.

It is, therefore highly probable that the sheep-dog's " basic ration " is often deficient in nicotinic acid; the significance of this will be discussed later under " black tongue."

Vitamin C : It is now generally accepted that vitamin C need not be present in the diet of the dog.

Innes (1931) showed that pups that were maintained upon a diet from which vitamin C was completely absent remained healthy for, at least, a period of 154 days. He also showed that such experimental animals synthesised the vitamin in their own tissues.

FEEDING: The Young Dog

It is particularly important that the level of nutrition of the sheep-dog should be wholly adequate during the period of growth and general physical development. This period begins while the puppy is still in its mother's womb and extends over the first 9 to 12 months of post-natal life, at about which time also the young dog enters upon his serious work. If he be fully nourished and physically fit at this stage then (other factors being equal) he possesses a quality of stamina that helps him greatly to withstand the rigours of his arduous life.

There is no doubt that (as will be discussed later) the feeding of the adult sheep-dog is often irrational and faulty but the ill-effects of malnutrition may be greatly reduced if the working collie has received adequate and proper feeding during his puppyhood and adolescence.

The Pregnant Bitch

Special attention must be given to the diet of the pregnant bitch, particularly from about the fifth week when the size of the fœtus begins to increase rapidly and thereafter progressively develops, especially during the last three weeks before birth.

Linton (1950) gives the maintenance food requirements of the pregnant bitch as about one and a half to twice those for maintenance in non-pregnancy; he suggests that the carbohydrates of the maintenance ration might be reduced by about one-third and that the proteins should be increased by about one half. It is difficult, if not impossible, to put this into practice on the rations at present available.

Feeding standards, of course, relate only to average requirements and, in point of fact, the nutritional requirements of the individual pregnant bitch cannot

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be accurately estimated; they vary widely in different animals and largely depend upon the size and the physical condition of the bitch herself and also upon the number of her fœtuses.

THE LACTATING BITCH

Fats and good quality proteins should be well represented in the diet of the nursing mother. Indeed, until the puppies begin to lap for themselves her needs for these substances become increasingly greater than the needs of the pregnant bitch.

The milk of the bitch differs in several important respects from that of the cow. Whitney (1949) gives the following comparative figures:—

	Bitch	*Cow*
Water ...	77.0	86.3
Protein ...	7.3	3.5
Sugar ...	3.7	4.7
Fat ...	10-12	4.0

From this it will be seen that bitch's milk contains more than double the amount of protein and about three times the amount of fat present in cow's milk.

PUPPIES

It is believed that the food requirements of a young, growing dog are at least twice those of an adult dog of equal weight (Arnold and Elvehjem, 1939).

Because bitch's milk is particularly rich in protein and fat it is generally agreed that the diet of the puppy after weaning should contain about 25 to 30 per cent protein and about 10 per cent fat. Cow's milk by itself is a poor substitute for bitch's milk.

While the period of growth is usually complete when the dog is about nine to 12 months old, the period of most rapid growth extends from the end of the fourth week to about the sixth month of age; consequently, at this time there is also an urgent need for bone-forming substances, namely, adequate supplies of minerals, particularly calcium and phosphorus, and also vitamin D.

The replies to the questionnaire indicate that immediately after weaning it is the common practice to give a diet composed of whole milk to which bread saps are added, and shortly thereafter to feed oatmeal porridge and milk as a staple diet. In many cases the pup, at quite an early age, receives the same rations as those fed to the older dogs except that milk is given whenever available and the feeds are increased in number to three or four daily. Table scraps including soup-stock are also given, especially to the younger puppies, and cod liver oil is a fairly common supplement to the rations.

(4) DISEASES

The English and Welsh returns did not furnish much information in respect of the incidence of disease and only the Scottish returns are considered here. These indicate that the most common diseases of the sheep-dog are: skin affections, reported in 25 per cent of the returns; distemper, 25 per cent; hard pad 3 per cent; worm infestation, 11 per cent; hysteria and "fits," 27 per cent; black tongue, 11 per cent.

Shepherds, in general, are somewhat reluctant to admit the occurrence of

disease in their dogs and it is probable that the above figures are too low. For example, rickets is reported in only one return, whereas it is known that this disease is of fairly common occurrence in young sheep-dogs. But since a rickety pup is considered unlikely ever to make a satisfactory worker it is usually destroyed.

Skin Affections : The references in the returns to diseases of the skin convey little information of value. This was expected because, under the circumstances, precise diagnoses were impossible. It is known, however, that parasitic mange commonly occurs in the sheep-dog and it is probable that a considerable number of the reports of " skin affections " are parasitic in character.

Distemper and Hard Pad : These virus infections do not seem to require any special comment here.

Worm Infestations are of common occurrence in the dog.

Hysteria : The name " canine hysteria " has come to be applied to a condition of mental disorder characterised by signs of acute apprehension and fear, often accompanied by hallucinations and unrestrainable seizures. The pathogenesis of the disease is not understood. Many cases are known to be of dietetic origin, and the association of " hysteria " with the feeding of wheaten flour, which has been treated with nitrogen trichloride or " agene " is now recognised. Symptoms simulating those of hysteria are, of course, caused by other than dietary factors, for example the presence of foreign bodies in the stomach, or heavy infestation of round worms or skin parasites. Attacks which resemble hysteria also occur as complications of distemper. In the present state of our knowledge the name " hysteria " must therefore be regarded as a generic term referring to a complex of symptoms which may be produced by widely varying factors.

Of the 194 returns from Scotland, 53 (27 per cent) reported the occurrence of " fits." In these 53 reports, 11 (21 per cent) mentioned bread or biscuit as forming part of the diet. In the 141 returns in which no reference is made to the occurrence of " fits," 13 (9 per cent) were fed bread or biscuit. Put in another way : of the 24 cases in which bread or biscuit was fed, 11 (46 per cent) reported the occurrence of " fits "; while in the 170 cases in which no mention was made of bread or biscuit, only 42 (25 per cent) reported the occurrence of " fits." The significance of these figures cannot at present be assessed; they are given here for what they may be worth.

The cause of the relatively high incidence of convulsive attacks in the sheep-dog must await further investigation.

Black Tongue : The affection of dogs known as Stuttgart disease or canine typhus closely simulates, and is probably identical with, canine black tongue (often called by shepherds " red throat " or " brown mouth ").

The disease bears certain resemblances to pellagra which for many years has been a scourge among the human populations principally of the southern U.S.A. and of countries of the Middle and Far East. Until recently the nature of pellagra remained obscure and was the subject of much speculation. Since it was endemic in maize-eating areas where the general level of nutrition

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was low and the choice of food limited, it was for many years believed that its cause was a toxin contained in maize.

In 1937 it was discovered that canine black tongue could be cured by the administration of nicotinic acid. This quickly led to the treatment being applied to human pellagra in which, however, although it caused a dramatic disappearance of some of the symptoms, it did not effect complete cure. It has since become recognised that pellagra is a multiple deficiency disease and that lack of nicotinic acid is only one of its causal factors; the disease is now successfully treated by a combination of various vitamins, particularly those of the B complex.

As has been indicated, maize contains some substance that is antagonistic to the proper assimilation of nicotinic acid and when the ration includes large quantities of maize the requirement of the dog for nicotinic acid is increased about three-fold.

Many proprietary foods for house dogs contain a large proportion of maize meal but it may be assumed that such foods are adequate in nicotinic acid since they contain other substances, for example yeast, which are very rich in the vitamin; they also usually include substances rich in the essential amino-acids, including tryptophane, which in itself is believed to be of importance in counteracting the effects of nicotinic acid deficiency (Krehl, *et al.*, 1946).

Black tongue is reported as occurring in 21 of the 194 Scottish returns—say 11 per cent—but I have reason to believe that the real incidence is even higher. Several reports from Scottish shepherds indicate that black tongue does not occur during lambing time and they attribute this to the fact that the dogs then have the opportunity of devouring the placentæ of the ewes. While the truth of such observations cannot be readily substantiated, it may well be that such a diet, rich in high-grade protein, provides an antidote to the "maize factor."

Since the "basic ration" is often deficient in nicotinic acid, the relatively high incidence of black tongue in sheep-dogs is readily understood.

Discussion

It would be remarkable if an animal, wholly carnivorous by nature, were able throughout his active working life to maintain health, continue to exhibit a high standard of intelligence and be capable of prolonged and intense bodily activity on an unvaried regimen for which he is neither anatomically nor physiologically fitted!

In point of fact the high standard of health generally attributed to the sheep-dog is more apparent than real. The active working life of a hill collie, while intense, is of relatively short duration and the arduous and exacting work which he performs is often the reflection of his inherent devotion to duty rather than of a high level of robust health.

(1) *Calories:* The Calories in the "basic ration" are adequate but in order to obtain the nutriment sufficient to supply the demands of body-maintenance and of energy-expenditure the dog must ingest a sad, lumpish, bulky mass of raw

or semi-raw cereal meal; and this is his staple diet day-in, day-out, throughout the whole course of his life.

(2) *Minerals:* The mineral content of the "basic ration" is apparently adequate with the important exception of calcium, which seems to be definitely low. This becomes the more significant in view of the high phytin content of the ration and the questionable adequacy of vitamin D.

(3) *Vitamins:* The vitamins appear to be adequate except for nicotinic acid, and possibly also riboflavin and vitamin D. The low content of nicotinic acid in a diet largely composed of maize appears to be the cause of the relatively high incidence of black tongue in the sheep-dog. While, at present, there is no clinical evidence that acute deficiency of riboflavin is common, it may well be that a marginal deficiency is at least partly responsible for the relatively short working life of the sheep-dog. It is now believed (Bicknell and Prescott, 1947) that riboflavin is intimately concerned in cellular respiration and in the metabolism of carbohydrate. It also appears to play an important part in maintaining the health of the cornea, lens and retina.

(4) *Special Requirements:* If these criticisms of the "basic ration" be justified in respect of the adult dog, it may be assumed that the ration is definitely lacking in the requirements of the pregnant and lactating bitch, and that it is also inadequate in the provision of such growth-promoting and bone-forming substances as are essential for the proper nutrition of the young, growing dog; for all these animals the diet should be generous and should include an ample amount of good-quality animal protein and of fat.

Animal protein and fat could best be fed as butcher meat and meat offals —if such foodstuffs were available for dogs to-day. Among the most important of the offals is liver which is not only rich in essential vitamins but has been shown to stimulate milk secretion in the bitch (Daggs, 1931). Milk should always be well represented in the diet of both the maternal bitch and the young puppy.

Recommendations

To meet these various criticisms I suggest that the cereal meal-brose could be reduced in volume and the diet greatly enhanced in value by the provision of a supplementary ration rich in animal protein and containing the requisite minerals and vitamins. The supplement must be inexpensive and possess good keeping qualities.

Such a supplementary ration might consist of: Horse or cow flesh and/or dried blood; mammalian liver by-products; fish-flesh and fish-offal meal; yeast, preferably irradiated; finely milled bone flour; common salt.

In the rearing of puppies and young dogs, if cow's milk be not available, a good quality milk-equivalent such as is used in calf rearing (but adjusted to the composition of bitch's milk) should also be employed.

In my opinion the adoption of such a change in diet, so radical but yet so simple, would be conducive to a real improvement in the health and general well-being of the sheep-dog.

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Summary

(1) The work of the sheep-dog is arduous and involves a great expenditure of energy.

(2) The study of his feeding and management has been neglected in the past; information on these subjects has been sought by means of a questionnaire to shepherds.

(3) The replies, covering 700 dogs, indicate that the sheep-dog's working life is relatively short, that his kennelling conditions are rough, and that his diet is monotonous and unbalanced.

(4) A critical study of the regular diet shows that it is not only unbalanced but that it is deficient in calcium, nicotinic acid, and possibly in riboflavin and vitamin D.

(5) The prevalent assumption that sheep-dogs in general enjoy a high standard of good health is ill-founded.

(6) The diet could be much improved, and the sheep-dog's health consequently benefited, by the provision of a supplementary ration rich in animal protein and adequate in the requisite minerals and vitamins.

Acknowledgments

I am grateful to all those (and they are many) who have helped me in this enquiry. They include veterinary surgeons, veterinary investigation officers, flockmasters and shepherds. Mr. W. T. Rowlands arranged the survey in Wales and translated the questionnaire into the Welsh language.

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SOME ASPECTS OF LOSSES IN FARM ANIMALS

(Concluded)

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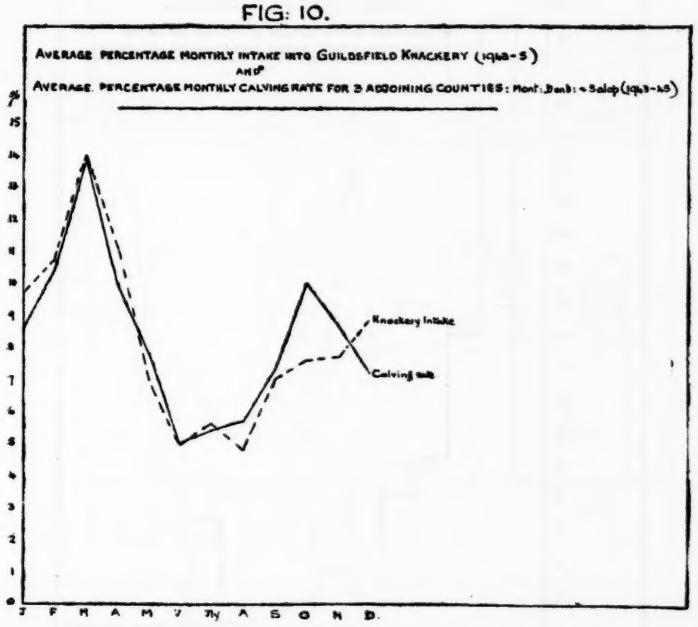
The April peak is very pronounced for the total cattle, for the cows and for other cattle, whilst the curve for horses is much more level showing the lowest intake during the summer months June, July and August.

FIG. 10.



In Figure 10 the average percentage of cows entering the Guilsfield knackery is compared with the average percentage of cows calving during the same period in the three counties of Montgomeryshire, Denbighshire and Shropshire. The similarity is marked. An October peak occurs in the calvings but there is no August peak in the intake.

An examination of this curve suggests that the incidence of summer mastitis is low in spite of the relatively high rate of autumn calving. This is in sharp contrast to the curves of the other knackeries which are situated in areas where the rate of autumn calving is relatively low. Only further investigation can establish the validity of this picture.

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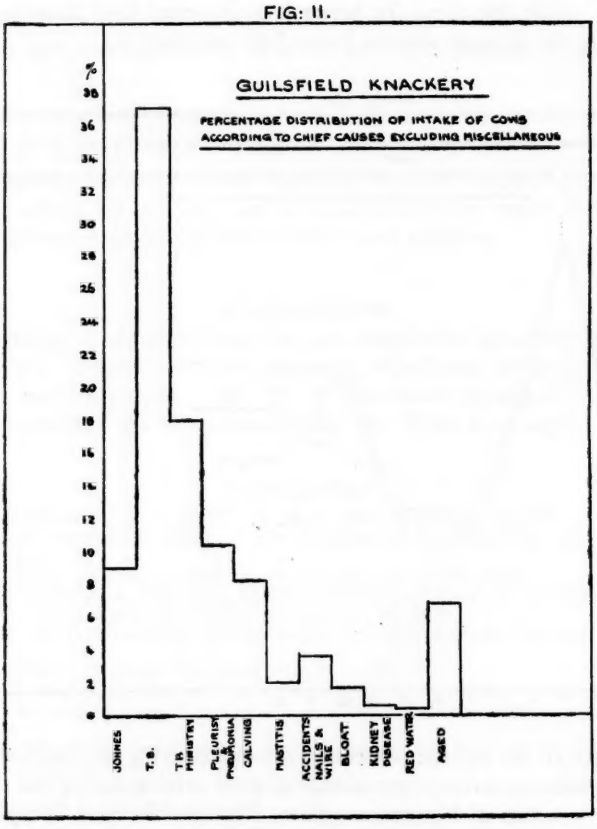
The records of the Guilsfield knackery contain a note or a word describing the cause of death or the reason for the disposal of each individual animal. Figure 11 illustrates the proportion of the more important disease conditions described by the knackermen in the carcases of cows.

The interesting feature of Figure 11 is the high proportions of Johne's disease, tuberculosis, including animals taken under T.B. order, pleurisy and pneumonia. Tuberculosis accounts for 55 per cent of the total specified and

FIG: 11.

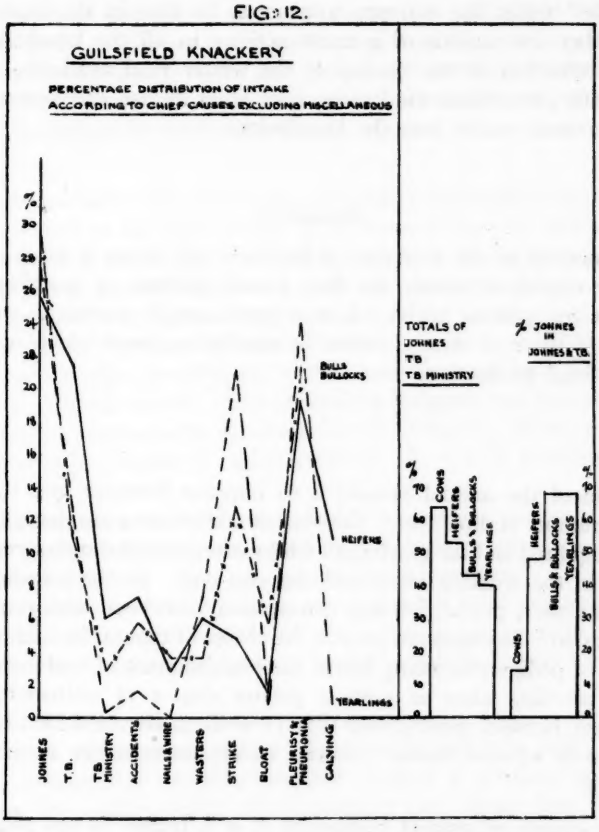


Johne's disease another 9 per cent, whilst pneumonia amounts to 10.4 per cent; cows taken to the knackery because of calving troubles are 6.4 per cent of the total.

Figure 12 illustrates the relative proportion of certain diseases occurring amongst bulls and bullocks, heifers and yearlings. In the animals in these three

groups, Johne's disease accounts for more than tuberculosis, although that is also high, whilst the number of animals taken under the T.B. order is relatively low. In these three groups of animals pleurisy and pneumonia account for over

FIG. 12.



20 per cent of the intake; "strike" is high for the yearlings. The histogram in Figure 12 shows the relative importance of Johne's disease and tuberculosis. Some interesting facts emerge on the correlation between age and incidence of these two diseases. Thus amongst the cows tuberculosis is highest while Johne's disease is lowest. On the other hand, tuberculosis is lowest and Johne's disease highest amongst the younger animals. The term "cow," as used by the knackerman, refers to an animal which has calved and the younger animals are those between 1 and 3 years old.

When making conclusions based on these knackery records it must be remembered that the diagnoses have been made by the knackermen, and their value depends upon the experience possessed by these people. Certain general

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conclusions may be safely drawn from the examination of the figures submitted. The entries in all four knackeries indicate the greater risks to which cows are exposed; over 50 per cent of all the knackery entries are cows. In the West Wales counties, horses appear to be exposed to greater risks than "other cattle" whilst the converse appears to be true in the Guilsfield area. March to May are periods of greatest activity in all the knackeries; this is probably a reflection of the quality of the winter food available. The risks associated with parturition, the incidence of grass disease and summer mastitis result in increased entries into the knackeries.

Discussion

The functions of the producer of livestock and livestock products may be conveniently considered under the four broad divisions of breeding, feeding, management and general health. It may prove useful to attempt to assess the significance of three of these divisions in relation to losses which occur in the course of animal production.

(1) *Breeding*

The aim of the animal breeder is to improve livestock and this may be sought in a number of directions. Thus speed and stamina are desirable qualities in the thoroughbred and the greyhound whilst strength and stamina are the qualities needed in the working horse and the gun dog. In the breeding of farm animals appearance, production and constitution (associated with general health and hardiness) are the standards used in the choice of parents in each generation. The essence of pedigree breeding lies in the establishment of uniformity of type, and strain breeding aims at even a greater degree of uniformity between individuals and between generations. When a uniform standard has been attained the influence of adverse factors operates widely amongst the members of the breed or type.

In any system of animal husbandry it is a truism to say that sufficient animals of the right quality must be bred if production is to be maintained or increased. The type of animal bred is a most important factor in determining the ceiling of production at any particular time. The actual rather than the potential production of any animal or group of animals is determined by factors of environment such as management, feeding and health. The losses occurring during production are a measure of success or failure to control these factors in the environment of the animal. Not only do environmental factors influence the actual production of all classes of farm livestock but it is also well established that the breeding of animals not adapted to the environment in which they are to live may lead to heavy, even disastrous losses. This has been well illustrated in the past when breeders, in an effort to increase the size and improve the fleece of hill sheep, have lost sight of the importance of hardiness as an

attribute of this class of animal. Bonsma in South Africa[12] has shown that imported British beef breeds fail to stand the heat as well as the indigenous cattle. A sound breeding policy should take cognizance of the basic environment; improvements in the environment should accompany an increase in the number of animals with higher potential production. Much of the mongrelism seen in the cattle population is the result of disappointments in pure breeding. Farmers have found that pedigree and performance are not necessarily the same thing and often do not go hand in hand; potential output is not attained because of limiting factors in the environment.

(2) *Feeding*

There is no doubt that one of the most important factors limiting production is insufficient food of the right quality at all times of the year and the same fact contributes towards losses sustained during the course of production. Knowledge of the principles of animal nutrition and the use of scientific methods of growing and utilising food have spread widely amongst the members of the farming community during the past half century, the production of individual animals and of farms has gone up materially and farmers' incomes have been multiplied several times. These are the signs of healthy industry but that there is room for considerable improvement is shown by the following facts:—

(1) Animal production is highly seasonal. It is high in summer and low in winter.

(2) The condition of the farm livestock is unsatisfactory as shown by the grading of the Collecting Centres and by the high proportion of the entries into knackeries in April. The winter diet is sub-standard.

(3) Production is low because in many districts predominantly concerned with livestock farming the length of the growing season is short and climatic conditions during harvesting operations lead to a relatively poor sample of corn and fodder.

These are well established facts and it is certain there is very little hope of improvement unless the standard of winter nutrition is raised. No single factor will achieve this desirable end but until it is achieved so closing the gap between the relative values of the summer and winter diets, much of the propaganda for better breeding is premature. When the gap is narrowed and closed then the average farmer will be in a position to maintain highly productive animals in a sound healthy condition. The purchase of large quantities of animal foods from overseas is not now possible; only the efforts of our own industry can ensure that farm animals are better fed in the winter time.

Management

General farm management is in many respects the most important function of these who derive their living from the soil. It entails long- and short-term planning as well as supervision of the day-to-day operations necessary for the growing of crops and the care of animals. The effects of good and of indifferent management are reflected in the general condition and production of farm animals and the crops upon which they feed.

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Skill in the management of livestock, and the word is here used in its widest sense, comes from intimate contact with animals over a long period. Many of the newcomers to the industry have not the necessary skill; it is to be regretted that present day trends favour the scribe and the man with capital but without experience.

We thank our colleagues for their interest shown in discussions on this subject, particularly Mr. E. T. Rees Evans, who has continued and extended some aspects of this work.

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THE PATHOLOGY OF NAVICULAR DISEASE

By G. T. WILKINSON, B.V.Sc., M.R.C.V.S.

Part I.—The Macroscopical Pathological Features of the Disease

A FEATURE which is quite frequently present in the early cases, although sometimes absent in later cases, is a discoloration of the central ridge of the tendinous surface of the navicular bone. The layer of fibrocartilage covering this elevation is stained quite a bright yellowish-brown, sometimes almost an orange colour. The superficial portion of the tendon in contact with this area very frequently shows the same discoloration, the area on the tendon matching almost exactly that on the cartilage. Oxspring (1935) noted a yellowish-brown discoloration of the tendon in contact with a diseased tendinous surface, and ascribed it to pigment derived from extravasated blood. He made no mention of the discoloration of the tendinous surface of the bone itself. Smith (1886) mentioned that a brownish pigment may be found on the surface of the cartilage and considered that it was probably derived from minute capillary hæmorrhage in the eroded tendon. Westhues (1938) described the assumption of a yellowish discoloration by the tendon as the first stage in the pathology of navicular disease. The present writer has observed this discoloration of the cartilage and

more especially of the tendon in navicular bones which were otherwise normal to careful radiographical and visual examination. In some cases, the tendon, although apparently normal in colour on its navicular surface, when sectioned shows a zone of the orange pigmentation just below the surface.

The nature of this pigmentation has been investigated during the course of the present study, and it reacts as if it was composed of fatty material. The pigment disappears when portions of the tendon are treated with fat solvents like chloroform or ether. When portions of the tendon are placed in a solution of osmic acid, the pigmented zone stains prominently brownish-black in colour. Frozen sections of the tendon stained with Sudan IV when viewed with the naked eye, show that the area of pigmentation is stained bright orange red. Microscopically the pigment appears to be fairly evenly scattered throughout the coloured area. In some places it is in close association with the nuclei of the tendon, in others it appears as quite large globules in the interstices between the collagen bundles, but mainly it occurs as very fine droplets scattered fairly diffusely throughout the collagen bundles of the area. It is interesting to speculate on the significance of this fatty pigment in the Flexor perforans tendon and the fibrocartilage of the tendinous surface of the bone, and on its relationship to the changes of navicular disease. Westhues (1938) believed that such discoloration was the initial and fundamental change in navicular disease, and based his opinion that the disease commenced in the tendon on the early appearance in the latter of such discoloration. Both Smith (1886) and Oxspring (1935) considered that the pigmentation was derived from extravasated blood, but apparently did not carry out any tests for hæmatogenous pigment. The discoloration seems to occur mainly in the tendons and fibrocartilage of old horses and it is probable that it is of a similar nature to the lipochrome pigment which occurs in the muscle fibres of the heart in the old human subject. The present writer has observed similar pigmentation of the flexor perforans tendon at the level of the fetlock joint in one or two old horses showing the pigmentation of the tendon also at the level of the navicular bone. It would therefore seem to be unlikely that the discoloration is of any significance in navicular disease, beyond illustrating the fact that the tendon and the fibrocartilage are probably the site of great activity during the animal's life. As noted earlier, the present writer has observed this pigmentation in navicular bones otherwise normal to careful examination and has often failed to find it in advanced cases of the disease. Navicular disease appears to be a common affliction of old horses, and it is possible that the occurrence of navicular disease in subjects, which independently show this senile type of pigmentation, accounts for the observed relationship between the two conditions.

Another early change which is noted in a number of cases is that the navicular ridge fibro-cartilage shows one or two areas where the normal bluish-white colour of the cartilage has been transformed into a dingy greyish-brown colour. Quite often the area is in the shape of a miniature navicular bone as shown in Fig. 1, and the area is duplicated on the opposing superficial portion of the flexor perforans tendon. Smith (1886) and Oxspring (1935) both described a purple discoloration

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of the fibro-cartilage in this area as one of the early features of the disease, and ascribe it to a hyperæmia of the underlying bone. No such purple discoloration has been observed during the present study, possibly due to the fact that all the specimens examined were obtained from horses which had been "bled-out" as completely as possible.

This greyish-brown colour was found to be the result of a thinning of the fibro-cartilage in this area, the actual colour being due to the subchondral bone showing through the remaining thin layer of the cartilage. The staining in the tendon extended down for some little distance from the bursal surface. An interesting feature is that the discoloured area on the tendon matched almost exactly the area on the cartilage fitting perfectly over it. This seems to indicate that the marking is probably the result of pressure when the animal is standing at rest, rather than a consequence of friction.

About the same time as this discoloured patch appears on the tendinous surface, numerous fine, pin-head erosions of the fibro-cartilage occurred in the same area (Fig. 2a). These appeared as dark brown spots against the normal bluish-white colour of the cartilage. If examined carefully with a hand-lens one can distinguish small yellow protuberances in the centre of some of these erosions. These small erosions with their tiny protuberances apparently correspond to the calcareous deposits, described by other authors, e.g., Williams (1899), as occurring in the macerated bone. Oxspring (1935) also described them as erosions of the cartilage. The origin of these erosions is not clear, but possibly they are the result of adhesion of individual tendon fibres to the fibro-cartilage, with subsequent tearing off of a tiny portion of the cartilage. This conjecture receives some support from the fact that in quite a number of these early cases the tendon is roughened and its surface shows a few fibres torn upwards. The fact that no fibres were found attached to the cartilage in any of these early cases, however, rather militates against the hypothesis.

About the same time as these changes become obvious, examination of the grooved portion of the lower edge of the diseased bones, reveals that the foramina situated there have undergone considerable enlargement and are now very prominent. The vessels passing through these foramina also appear to be rather dilated.

Actual erosion, of any noteworthy size, into the substance of the bone has not been observed in any specimen in the absence of adhesions between the tendon and the fibro-cartilage. That such cavities do occur without adhesion seems to have been the experience of Oxspring (1935), who also made the interesting observation that, once established, such cavities do not appear to undergo any further increase in size over long periods of time. In the present author's specimens, several showed large erosions of the fibro-cartilage and the subjacent bone, but in every case these were accomplished by large scale adhesions of the tendon to the fibro-cartilage. In a few cases there was erosion of the fibro-cartilage only, and in these cases the tendon showed evidence of excessive wear. There was usually a stripping upwards of a large number of the superficial fibres of the tendon, the appearance suggesting that the fibres had been torn and had

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PLATE I

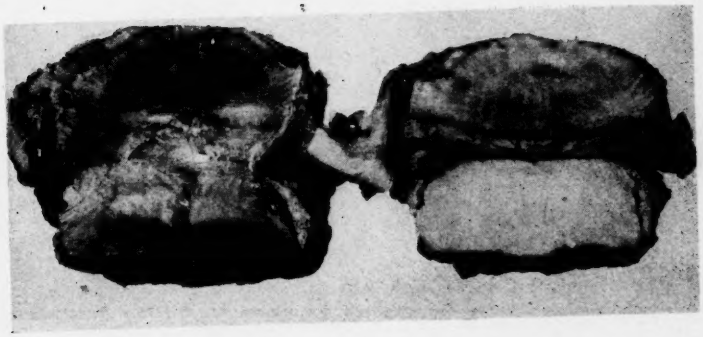

FIG. 1

A B

FIG. 2

(Article by Wilkinson, page 38)

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PLATE II

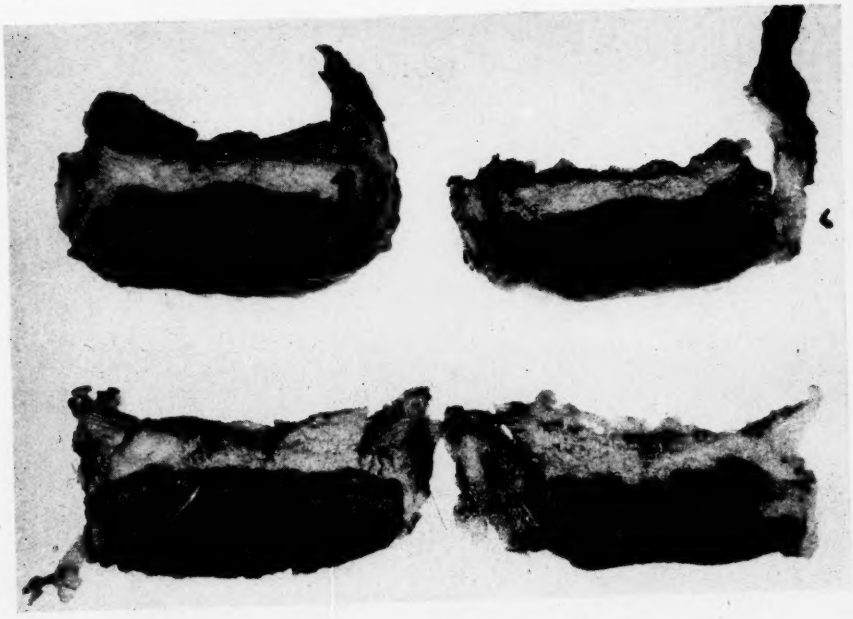

FIG. 3

(*Article by Wilkinson, page* 38)

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then curled upwards due to their own elasticity (Fig. 2 (a), (b)). As Oxspring (1935) noted, the fibres are apparently torn from a point opposite the lower edge of the bone, usually quite a distance below the level of the erosions, and the tearing continues up to the superior limit of the navicular bursa. Only the fibres in the central area of the bursal face of the tendon are apparently affected by this tearing. The erosions on the tendinous surface of the bone have always been found in the immediate vicinity of the navicular ridge and never towards the margins of the tendinous surface.

Several of the specimens examined showed varying degrees usually advanced of adhesion between the flexor perforans tendon and the fibrocartilage of the tendinous surface (Fig. 2 (b)). These adhesions make it difficult to open up the navicular bursa and expose the lesion, and it is often necessary to incise the adhered portion of the tendon before this can be accomplished. These adhesions are often in the form of cylindrical bands of vascular granulation tissue entering the substance of the bone through circular areas of erosion in the tendinous surface. Frequently there are two such adhesions and they are invariably located on or near the vicinity of the navicular ridge, in the same area as erosions of the fibrocartilage occur in the early stages of the disease. Possibly the circular appearance of the rarefied areas in the bone often noted radiographically, is due to these cylindrical bands of soft tissue being aligned "end-on" to the rays.

New bone formation can be appreciated on the upper edges of diseased navicular bones, often when only slight macroscopic lesions are otherwise present. The new bone apparently forms in the fibrocartilage and ligamentous tissue of the upper edge and renders them hard and unyielding to the touch at their junction with the bone. By the time adhesions have formed, bone formation is often and considerable, but not an invariable, accompaniment of the changes. The extent of this new bone formation can only be really appreciated by the use of radiography or by maceration of the bone, as the new bone tissue is masked from view by the tissues surrounding it.

Examination of affected bones has also been made by sawing through the bone at various levels parallel to the tendinous surface (Fig. 3). In the early stages of the disease, if such sections are made at the level of the enlarged nutrient foramina, several apparent ingrowths of tissue can be seen penetrating the substance of the bone, mainly from the lower edge, although one or two finer strands of tissue are often present in association with the upper edge. The areas of soft tissue in the region of the lower edge are apparently continuous with the nutrient foramina of the edge. In the centre of some of these soft tissue areas a dilated blood vessel can often be distinguished with the naked eye. These soft tissue areas are greyish-red in colour, and show up prominently against the normal creamy-white colour of the remainder of the bone. The margins of the areas are rather indefinite, and running from them one can distinguish thin red lines, which closer examination with a hand-lens reveals as small dilated blood vessels. Similar sections of an affected bone at this stage of the disease made nearer to the tendinous surface, shows considerable con-

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gestion of the plexus of blood vessels beneath the fibrocartilage. This appearance can be better examined by carefully paring away the cartilage until the immediate subchondral area is exposed.

When adhesions have occurred, a similar section of the bone made at a level a little distance below the tendinous surface, shows varying degrees of bone destruction and its replacement by a greyish-red granulation type of tissue. In such a section these areas are often circular in outline, but their margins are rather vague and indistinct. If several sections are made at levels moving away from the tendinous surface, the areas become progressively smaller, and when the level of the nutrient foramina is reached, connection between the now small areas of bone destruction and the soft tissue areas continuous with the foramina can be seen to be established.

The upper edges of affected bones sectioned in this way, often show new bone formation in the form of small outgrowths of the parent bone into the fibro-cartilage and ligamentous tissue of the edge.

The most noticeable portion of the synovial membrane of the bursa, i.e., the villous portion on the bursal surface of the fibrous sheet just above the upper edge of the bone, does not reveal any noteworthy or constant macroscopical change in the affected cases. Sometimes it appears slightly congested, sometimes it is apparently hypertrophied, but often it is perfectly normal macroscopically.

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THE HARRY STEELE-BODGER MEMORIAL FUND

History records that, throughout the ages, certain men have influenced the progress of events to a far greater extent than did any of their contemporaries. There have been occasions when the destiny of nations has been changed completely by such men. The change has not been to the common good always, but there is ample evidence that times of great trouble and anxiety stimulate the appearance of a leader who can infect his fellows with his own exuberance and compel them to great effort.

This phenomenon is not confined to the affairs of nations; it can and does occur in professional circles. We of the veterinary profession have good reason to be thankful, for we have not lacked great leaders in the past, and it is right that we should hold their memory in proud and grateful remembrance. Harry Steele-Bodger was a great leader of men who came to his zenith in 1939, when our country was entering a time of great peril, when his profession was filled with apathy coincident with unemployment and financial stress. He came to power a supreme optimist as regards the future destiny of the profession, and he refused to accept the black side of things. His enthusiasm was contagious and in a short time he wrought a complete revolution in our outlook.

He stimulated those in authority, he spurred the somnolent to action, he compelled stock-owners to recognise and appreciate the value of an efficient veterinary service. The farm gates were opened again, and there can be no doubt that the great increase in milk production which did so much to preserve the health of the nation in its time of peril was in no small measure the result of his efforts.

His campaign led to a great upsurge in veterinary work on the farms, unemployment in the profession was swept away, and the present satisfactory position in this regard is a tribute to his foresight and vision.

The profession, and especially the younger veterinary surgeons, owe a great debt to Harry Steele-Bodger, a debt which they can never repay, but they can show gratitude and respect for his life and work by supporting the scholarship fund which has been launched to revere and perpetuate his memory.

The fund will enable a scholar to do something which was near "S.-B.'s" heart, for he was always a scholar and a great mixer amongst men. He would have said: "Go and meet friends, learn and teach, and bring back anything which is good for the profession and our patients."

We commend the H.S.-B. Memorial Fund to our readers, with the hope that they will support it to the utmost of their ability, so that our memory of a great veterinary surgeon may never grow dim.

A Memorial to the late Harry Steele-Bodger

The British Veterinary Association has inaugurated a fund to endow a memorial to the late Harry Steele-Bodger, President during the years 1939-41, and Chairman of the Survey Committee, 1939-46. The Memorial will take the form of a Travelling Scholarship for Veterinary Surgeons.

It is hoped that all members of the profession will give their generous support in memory of one who, with his colleagues, did so much to further the aims and aspirations of the veterinary profession and to extend veterinary practice in its widest sense to each and every farm in the country.

The fund is open to all—both within and without the profession—who would wish to pay tribute to the late Harry Steele-Bodger's work for the profession, for agriculture and for the country.

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His colleagues within the profession will be aware of the tremendous effect of the war-time endeavours which he so ably and so tirelessly led.

Those in agriculture will be aware of the lasting benefit of that closer association with the profession forged by those endeavours and of the benefits which have accrued.

Organisations, societies, business interests and individuals outside the profession who may wish to lend their support will be welcomed as subscribers to the memorial.

The members of the Appeal Committee are:—

The Officers of the Association:—

Mr. A. M. Graham, President,
Mr. A. J. Wright, Senior Vice-President,
Mr. A. Thomson, Junior Vice-President,
Mr. H. E. Bywater, Hon. Treasurer, B.V.A.
Mr. H. F. Hebeler, Hon. Secretary, B.V.A.,
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Mr. S. L. Hignett, Hon. Treasurer,
Mr. R. F. Armour,
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Mr. J. A. Brown,
Professor T. G. Browne,
Professor H. G. Lamont,
Dr. R. F. Montgomerie,
Miss Rosa Smith, Hon. Secretary,

together with some other veterinary surgeons, known to the above Executive Committee as friends of the late Harry Steele-Bodger, who have been invited to join the Committee.

All donations should be sent to the Hon. Treasurer of the Appeal Committee:—

S. L. HIGNETT,
Steele-Bodger Memorial Fund,
British Veterinary Association,
36 Gorden Square,
London, W.C.1,

and cheques, postal orders, etc., should be made payable to the "Steele-Bodger Memorial Fund."

REVIEWS

BIBLIOGRAPHY OF THE PUBLISHED WRITINGS OF SIR ALMROTH E. WRIGHT, edited by Leonard Colebrook. 32 pp. 1952. London: William Heinemann. Price 6s. net.

LEONARD COLEBROOK has rendered a great service in editing this bibliography of a great man; the extent of his greatness peeps out here and there in the comments made on the contents of his books and papers. Almroth Wright's name is associated with immunisation, with glass tubing techniques and with the training of young men who in their turn have become eminent. It is strange to read of a paper on "Woman's Suffrage from the Ethical Standpoint" and to learn that he had such outspoken and unchanging opposition to this question. This is the more remarkable when viewed against his wide culture, which he revealed in the small volume "Prolegomena to the Logic which Searches for the Truth," a book which received great praise from Bernard Shaw. It was published by him at the age of 80 when he heard "the horse-hoofs of Eternity bidding him hurry." This is consistent with his fear that he might "sail away across the seas without having unloaded his cargo upon the quays." The mass of cargo is here listed with revealing comments by Colebrook; there are 12 books and 132 papers and published letters. There is a great variety, and enough ideas are left lying about to stimulate many young workers in many branches of medical and allied sciences. Wright himself considered that one of his most useful contributions to medicine was his work on the addition of sodium citrate to cow's milk when used for infant feeding; a procedure which has its uses in veterinary work. The paper was published in 1893. At the age of 81 Wright quoted Goethe "Errors always matter; but how very much they matter becomes clear to a man only at the end of his way." In spite of this sombre note his humour was displayed when he wrote at about the same period, "the vocabulary of statistical experimentation . . . is distressingly defective." He claimed that it failed to make distinction between different kinds of "controls" used in such

experimentation and that it is unfortunate in the un-precise use of the word "significant."

It is an excellent bibliography and worthy of the man it commemorates and of his pupils; the names of many are linked with his in the titles and they in turn have become famous.

INTRODUCTION TO VETERINARY THERAPEUTICS, by George F. Boddie, B.Sc., M.R.C.V.S., F.R.S.E. Edinburgh: Oliver & Boyd, Ltd. Price 15s. net.

THE author is to be congratulated on attempting what many have considered and avoided, namely, a concise and comprehensive review of the fundamentals of Veterinary Applied Pharmacology.

It is widely agreed that such a book has been required for many years. There will, no doubt, be less agreement concerning the way in which Professor Boddie has presented this work, and also regarding the relative value of the book when compared with "Veterinary Diagnosis" by the same author.

The major part is devoted to brief illustrated definitions of the various drug groups, system by system, each chapter being concluded by a dosage table of the drugs mentioned therein. Less acceptable are the preliminary chapters devoted to "The Elements of Materia Medica," which may provoke controversy by not adhering strictly to traditional and officially accepted form. Another controversial issue will doubtless be the indiscriminate usage of various proprietary names, particularly in the chapter on Chemotherapeutics, which may be confusing to the student. Inconsistencies occur in the text which also tend to confuse; why explain in the Poison Regulations that it is essential for a signed order to carry the prescriber's qualifications, and yet omit these same qualifications from an example of a "complete prescription" which includes a scheduled drug?

However, despite inconsistencies and errors, the book will be received by the veterinary profession as an acceptable innovation that will become indispensable to the student as the framework to which he can attach the immense mass of detail he is expected to remember.

THE CONTROL OF COMMUNICABLE DISEASES, by Hugh Paul, M.D., D.P.H., Medical Officer of Health, Smethwick County Borough, with a foreword by G. S. Wilson, M.D., F.R.C.P., D.P.H., Director of the Public Health Laboratory Service. 526 pp. with numerous tables and figures. London: Harvey & Blythe. 1952. Price £2 15s. net.

THE foreword tells us that epidemiology is the study of the reaction between the parasite and its environment and, as both are subject to change, epidemiology is, and always must be, a live subject. The penultimate paragraph of the book tells us that the triumphs of the future, in the prevention of disease and the enhancement of health, will be no less satisfying and no less comprehensive than the triumphs of the past. This book has been written with these objects in

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view and with this faith, and it is realised that the tasks of the future call for a high degree of co-operation between a variety of workers, and lie only partly within the province of the medical profession. It is for this reason that the attention of veterinary workers is called to a book which they will appreciate; although it is written by a medical officer of health and primarily for medical workers.

The book is well balanced and the 39 chapters are in sections dealing with the household diseases, the epidemic scourges, the diseases associated with food and water, and the neurotropic infections. Other sections consider the controls of communicable diseases and attention is paid to intermediate vectors, quarantine, isolation, disinfection and other procedures; some of them need legislation. The prologue is excellent and likens the study of epidemiology to the brutal struggle between man, beast and reptile, between man and beast, and above all between man and his fellow man. The battle of man for food and the food supply of the world are discussed, and once again it is emphasised that the total population of the world must not be greater than can be fed. Pestilence has been an erratic means of keeping down populations, and the great killing diseases of mankind are becoming subject to the control of man . To-day the alternatives are wars and starvation; the starvation method is proving successful, for men are dying from the inadequacy of the food available, and there is much wastage from animal disease. It is in this field that the veterinary surgeon plays his important part, and he should take a glimpse at the problems of the human race; he is involved as an individual and also as a professional man.

The author gives evidence of his wide reading but not of the depth to which he should have gone; he has not contented himself with reading only that which is strictly of medical interest, but has revealed the outlook of the biologist. This adds to the attraction, but there is the irritating habit of referring to authors with no corresponding name in the bibliography. At other times the name or initials of an author are wrongly given; Stuart and Harris should read Stuart-Harris, neither Stanley nor Fred Griffith added the letter "s" to their names, Davies, C., should be Davies, G. O.; the original work of Rosher and of Straker on the incidence of *H. influenzæ* is recorded in a Ministry of Health report and the authors are, Straker, Hill and Lovell, with observations by Rosher and Cole. There are also some errors in the actual text and it is obvious that the connection between pulmonary tuberculosis and milk is a mistake for abdominal tuberculosis; antitoxin and not exotoxin is meant in the second paragraph on page 54.

The author's viewpoint in many parts will annoy some and please others; he considers the available information about rubella in the mother and abnormalities in the offspring to be vague and inconclusive, and he is not clear as to the advisability or not of swabbing the throats of children in a school in which a single case of diphtheria has occurred. The homily directed to the miserable victim of the common cold who goes forth spreading infection in mistaken zeal, is delightful. His position as a medical officer of health reveals itself when he

"plays for safety" in some circumstances and this is well exemplified in his discourse on the difficulties of the diagnosis of smallpox.

He is not on safe ground in his appraisal of animal infections which might have a bearing on human disease, and he should have sought the advice of a student of comparative medicine. The silly statements made would have been avoided, and we should not then read that " neither infectious nor serum hepatitis appear to be found naturally in the lower animals "; neither should we be told that " the human type of tubercle bacillus is capable of causing disease in animals, but this is not common." Dogs play an important part in the life of a large number of people, and most cases of tuberculosis in the dog are due to the human type of bacillus, and a specific hepatitis is recognised. The wrong emphasis is given in the statement that " the work done by Griffith and Lancefield . . . enabled the mastitis of cattle to be differentiated from streptococcal infections commonly found in human beings." Another statement open to doubt and to irritation is that " the cows should be examined and if necessary a veterinary inspection should be carried out "; what exactly does that mean? Other excerpts, equally ambiguous or misleading, could be quoted, which suggest that the author has been content to accept reviews instead of original articles, and the review is not always reliable unless one is acquainted with the writer. The attack he makes on the control measures against bovine tuberculosis is not a well-informed one, and there would be less harshness if the author appreciated the progress of the eradication and attested herds schemes during the last two or three years; the years he refers to covered the war and immediate post-war period and progress was slow. It is, however, pleasant to read of the praise accorded the investigation of a certain milk borne outbreak of *S. dublin* infection in children; the author cannot have known, for it is not recorded, but the investigators of that outbreak requested, received, and accepted guidance from a veterinary bacteriologist.

It is a good book nevertheless, and it serves to point out once again the limitations of the medical man when discussing matters of a comparative-medical interest. There is so much to learn from the student of comparative medicine; the writing on epidemiological subjects would be more valuable if that aspect of the subject was as well dealt with as the purely medical part.

THE FARMER AND STOCK-BREEDER YEAR BOOK, 1953. $8\frac{3}{4}$ in. x $5\frac{1}{2}$ in. 390 pp. Over 130 illustrations. London. Price 10s. 6d.

WITH the 1953 volume *The Farmer and Stock-Breeders' Year Book* reaches its 77th edition. It therefore really needs no introduction or recommendation to anyone. The reference section increases each year and on this occasion additional statistical material has been added on such subjects as Farm Pro- interest. There is so much to learn from the student of comparative medicine; the writing on epidemiological subjects would be more valuable if that aspect industry.

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NEWS

ANIMAL HEALTH TRUST

A Scientific Advisory Committee has just been formed to assist the Animal Health Trust in the development of its research programmes, and to advise the Trust on the granting of various educational awards which are an integral part of its work.

Professor J. B. Buxton, F.R.C.V.S., Principal of the Royal Veterinary College, has been elected chairman of the committee and Sir Frank Ware, Veterinary Adviser to the Canadian Government in London, deputy chairman. The other members of the committee are:—

Professor W. I. B. Beveridge, D.V.Sc., Department of Animal Pathology, University of Cambridge; Dr. Kon, Head of the Nutritional Department of the National Institute of Research in Dairying; Dr. T. Moran, C.B.E., D.Sc., Director of Cereal Products Research Association; Professor C. W. Ottaway, F.R.C.V.S., Department of Veterinary Anatomy, University of Bristol; Dr. A. W. Stableforth, D.Sc., D.V.S.M., M.R.C.V.S., Director of Veterinary Laboratories, Ministry of Agriculture, at Weybridge; the Rt. Hon. Lord Stamp, B.Ch., M.A., M.B., British Post-Graduate Medical School; Dr. E. L. Taylor, D.V.Sc., M.R.C.V.S., the eminent veterinary parasitologist; Dr. F. A. Cooper, M.A., A.M.I.Chem.E., of the Cooper Technical Bureau, Berkhamsted.

As a result of the formation of this committee, it will be possible to ensure that the research work done in the Animal Health Trust's four research stations—respectively for farm livestock, horses, poultry and dogs—will not overlap with animal research being done elsewhere.

In addition to becoming chairman of the new committee, Professor Buxton was elected a member of the council at the Annual Meeting of Trustees and Council, presided over by His Grace the Duke of Norfolk, President of the Trust. Mr. J. N. Ritchie, B.Sc., M.R.C.V.S., Chief Veterinary Officer of the Ministry of Agriculture and Fisheries was elected a member of the council also.

Publishers' Notices

The British Veterinary Journal, with which is incorporated The Veterinary Journal, is published monthly, and copy for advertisements should be in the hands of the advertisement manager not later than the 20th of the preceding month, if proof is required. Tel.: Temple Bar 3386.

Letters for the Journal, literary contributions, reports, notices, books for review, exchanges, new instruments or materials, and all matter for publication (except advertisements) should be addressed to the Editor.

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